

South Dakota State University
**Open PRAIRIE: Open Public Research Access Institutional
Repository and Information Exchange**

Electronic Theses and Dissertations

1950

A Study of a Fused Course in Physics and Chemistry for Watertown High School

Gerhart C. Hertz

Merle T. Meinicke

Follow this and additional works at: <https://openprairie.sdstate.edu/etd>

Recommended Citation

Hertz, Gerhart C. and Meinicke, Merle T., "A Study of a Fused Course in Physics and Chemistry for Watertown High School" (1950).
Electronic Theses and Dissertations. 2216.
<https://openprairie.sdstate.edu/etd/2216>

This Thesis - Open Access is brought to you for free and open access by Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. For more information, please contact michael.biondo@sdstate.edu.

A STUDY OF A FUSED COURSE IN
PHYSICS AND CHEMISTRY
FOR
WATERTOWN HIGH SCHOOL

by

Gerhart C. Hertz
and
Merle T. Meinicke

A problem submitted to the Faculty of South Dakota
State College of Agriculture and Mechanic Arts
in partial fulfillment of the requirements
for the Degree of Master of Science
(Plan B)

SCUTH DAKOTA STATE COLLEGE LIBRARY

ACKNOWLEDGMENT

The writers hereby wish to express their sincere appreciation to Dr. C.R. Wiseman, Head of the Department of Education of South Dakota State College for his advice and patient counseling in setting up and working on our problem.

The writers wish to thank Supt. D.D. Miller and Prin. D.W. Tieszen of the Watertown Public Schools for giving us permission to conduct the problem in the Senior High School.

TABLE OF CONTENTS

Section	Page
I. Introduction	1
Present Pattern in Science Education	
Science Education in South Dakota	
The Science Curriculum in Watertown Schools	
Purposes and the Procedure of the Study	
II. Review of Literature Dealing with Fused Physical Science	9
III. Description of Groups in Study	17
IV. Content and Teaching Procedure Used in the Fused Course in Physics and Chemistry.	21
Selecting the Content	
Outline of Content	
Comments on Outline	
Teaching Procedures	
V. Testing and Test Results	41
Testing Used as Part of Teaching Procedure	
Testing Used for Comparative Purposes	
VI. Summary and Conclusions	54
Recapitulation	
Conclusions	
Recommendations	
VII. Bibliography	59
VIII. Appendices	
A. Handbooks and Reference Books	61
B. Sample Worksheet	62
C. Suggested List of Teacher and Pupil Demonstrations for the Fused Course.	63
D. Sample Unit Test	64
E. Final Examination	65
F. New California Short-Form Test of Mental Maturity, Advanced '47 S-Form	66
G. United States Armed Forces Institute Test in Senior Science	67

LIST OF TABLES

TABLE	Page
I. Mental Ability Scores in Terms of IQ of All Pupils Who Participated in the Testing Program-----	18
II. Scores Made by Pupils in Fused Course in Final Examination-----	43
III. Analysis of the USAFI Test in Senior Science and Writers' Final Examination as to Area of Question-----	45
IV. USAFI Test Scores of All Pupils Who Participated in the Testing Program-----	47

FIGURE

I. Scattergram of USAFI Test Scores and Mental Ability Scores of All Pupils Participating-----	51
--	----

INTRODUCTION

Within the last half century, the educators of this country have been reviewing and revising the educational objectives, curriculum content, teaching techniques, evaluation of educational outcomes, and the administration and organization of schools. This has been done to gear our educational system with the newer concepts in educational psychology, mass education, industrialization, and the changing social, economic and political conditions.

The knowledge of science and, concomitantly, the teaching of science have advanced more than in any other similar period of our history. The impact of this advancement can only be partially comprehended, and we in science education must act to the best of our abilities to meet this changing order. The responsibility is enormous, but not unsurmountable.

From the early beginnings in the field of science, the various phases of science were not easily distinguishable. A knowledge of a scientific nature was often referred to as a knowledge of "dark things". The early scientists were looked upon as men having a working relationship with spirits of another world, as was Otto Von Guericke and his water barometer. As man's knowledge and understanding grew, the less mysterious it became, even if it did become more technical. Diversification of the study of science evolved, but it was soon realized by educators that too much specialization

did not meet the needs of the young student in high school.

Present Pattern in Science Education

Over the years and decades the reorganization of science in high school seems to have been somewhat away from special and separate sciences, especially in the ninth and tenth grades. It has led towards more generalized science courses in those grades. Early curriculum studies show that one would find in the ninth and tenth grades science courses such as botany, zoology, physiology, physiography, and physical geography. The Committee for the National Society for the Study of Education makes the following statement:¹

In spite of the rapid expansion of scientific knowledge and the even more rapid expansion in applications of science and practical invention, the percentage of high-school pupils enrolled in science courses has continued to decline. From the latest available data it is evident that there have been increases in percentages of enrollments in the generalized courses in science, general science, and general biology. In contrast, percentages of enrollments in specialized sciences have, in general, steadily dropped during a forty-four year period. Further, the evidence reveals that astronomy, geology, botany, zoology, and physical geography have practically disappeared from the science programs of the high schools.

In the place of the specialized courses have come combined science courses, as general science in junior high school, or in the ninth grade, and biology in the tenth grade. Chemistry and physics were taught in the eleventh or twelfth grades and largely still retain

1. "Science Education in American Schools", Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, 1947, p. 137.

their position there in those schools which teach one or two science courses in the eleventh and-twelfth grades. The point to see is that starting about 1910, general science, as a combined science, came into the ninth grade supplanting the special science courses there. A little later, biology, as a combined science course, came in largely supplanting botany, zoology, and physiology as separate courses. In later years some thought has been given to setting up a combined physical science course made up largely of content from physics and chemistry in a one-year course in the eleventh and twelfth grades.

Science Education in South Dakota

The general pattern of science courses being offered in South Dakota seems to follow the pattern as found throughout the country. This is well substantiated by a study made by Dr. C. R. Wiseman, South Dakota State College, in which he investigated the credits presented by students from South Dakota schools over a period of twenty years beginning in 1922. He found the number presenting credits upon entering South Dakota State College in general science had increased by about one hundred twenty-five percent. Biology had increased four hundred fifteen percent over the same period, while physics had dropped forty percent and chemistry had increased one hundred fifteen percent. Physiology decreased by about eighty percent, while botany, zoology, physiography, geology and others had practically disappeared.

A study by Lloyd V. Manwiller at South Dakota State College enriches the picture. The general pattern of high-school science in South Dakota high schools is either two years, three years, or four years. These three categories cover about ninety-six percent of high schools in South Dakota. A breakdown of these three divisions shows that the two-year course comprises about twenty-two percent, the three-year course thirty-seven percent, and the four-year course thirty-seven percent. About two percent of the schools have one year of science, and about two percent have five years of science. In terms of science subjects, it is meant, general science, biology, chemistry, and physics. The State Department of Public Instruction recommends general science in the ninth grade, biology in the ninth or tenth grade, and chemistry and physics in the eleventh or twelfth grade. The State Department also recognizes other units or half units in science under such titles such as physical science, geology, physical geography, aeronautics and physiology. These subjects do not appear in the curriculums of many South Dakota high schools.

When two sciences are offered in a school they customarily are general science and biology. When three sciences are offered, usually they are general science, biology, and either chemistry or physics. When four sciences are offered, then all four mentioned are given. A definite minority of our schools have junior high-school organizations. Where it does exist the type of junior high-school organization is of

the 6-6, or 6-3-3 type. This influences somewhat the pattern of science for that school. Most of the larger high schools in South Dakota have the junior high-school organization in one form or another.

A more specific picture of chemistry and physics courses, according to the same study by Lloyd V. Manwiller, shows that of 289 schools in South Dakota, seventeen percent offer chemistry and no physics, nineteen percent offer physics but no chemistry, and about forty-one percent offer both physics and chemistry. Approximately twenty-three percent offer neither chemistry nor physics. Adding percentages, it is found that about fifty-nine percent of the schools, and these are mostly the small schools, offer only chemistry, or only physics or neither of the aforementioned. It might seem expedient then, for these schools to consider a course which may make it possible to offer a fused one-year science course of chemistry and physics.

The Science Curriculum in Watertown Public Schools

In contrast to the average high school in South Dakota which is the 8-4 plan, the Watertown school system is set up on the 6-3-3 plan. The enrollment in the junior high school is slightly over five hundred pupils, while the enrollment in the senior high school is slightly greater.

In the Watertown schools, science is required in the seventh and eighth grades. The seventh-grade science class meets five times per week, one hour per day, and deals mainly

with the study of health, mental hygiene, and knowledge of a very general scientific nature. In the eighth grade, the science class meets three times per week, one hour per day, and covers material of a very general nature in the fields of biological and physical sciences. It is mainly a course for exploration and development of motivation for further study in science. A check of the records in the school system shows that about twenty percent of the pupils in the ninth grade enrolls in general science which is an elective course. In the tenth grade we find that about ninety-eight percent of the class meets the school's requirement for a laboratory science by enrolling in biology. About thirty-five percent of the students in the eleventh grade enroll in chemistry and somewhat more than twenty percent of the seniors take the course in physics. These are the standard courses with laboratory and conventional texts. Enrollment in chemistry is limited almost entirely to juniors, and the same is true with physics and seniors. The number of boys and girls in chemistry is about half and half, while in physics, boys definitely predominate. Other science courses offered in the senior high school include aeronautics and physiology. The last two mentioned are semester courses with one section of each composed of both juniors and seniors.

At graduation, about two percent of the graduates have five science units, six percent have four science units, twenty percent have three science units, thirty-five percent have two science units, and all or one hundred percent have

at least one unit in science. It appears that there are too many students who do not have an opportunity to study the physical sciences, referring specifically to chemistry and physics. During the past decade, the writers have noted that in the Watertown schools, about sixty percent of the graduates had no course in either physics or chemistry. This indicates that a need of the students is not being met in the physical sciences.

A senior science course which had been offered in the eleventh and twelfth grades was evaluated in terms of the needs and interests of the present-day students. This course was of the "consumer type" science course, and dealt mainly with the economic aspects of everyday living. It was felt that such a course, or any of the other so-called physical science courses, did not adequately meet these needs. Many of the students, who took the course in senior science but did not enroll in chemistry or physics, were going to college, or going into trades or the military service where a better understanding of the principles of physics and chemistry were both useful and desirable.

Purposes and Procedures of the Study

The writers had in mind the modification of the present science curriculum in the Watertown High School. In doing this, they sought the answers to the following questions: Can physics and chemistry be fused into a one-year course for pupils who do not enroll in the conventional physics

and chemistry classes? Will such a course be feasible and workable? What content will be included? How will it be taught? How will the laboratory work be handled? Can it be adapted to the interests and ability levels of the pupils? Will the achievement of the pupils in this fused course be comparable to the achievement of the pupils in the other physical science courses?

In attempting to find the answers to these questions, a review of the work which had already been done along the line of fusing physics and chemistry was made. Objectives for science teaching in high school were sought. An outline of content for the fused physics and chemistry course was developed and revised. The course was taught by the writers, each having a section, for a period of one year, and the achievement of the pupils in the fused course compared to those in the conventional physics and chemistry classes. The detailed procedure for these are to be found in the following sections of this study.

REVIEW OF LITERATURE DEALING WITH FUSED PHYSICAL SCIENCE COURSES

Within the past fifteen or twenty years a great deal of work has been done in the field of surveying our present science curriculum in secondary schools. Local school administrators have had their teachers review and discuss the objectives of their respective fields of teaching in the light of present-day needs and pupil interests.

Today, the supervision by progressive administrators has made it possible for teachers in the various fields to view their subjects as part of the entire program of studies and revise them when the need occurs. Teachers have also shifted the emphasis in the classroom from that of concern for subject matter alone to a study of the individual and his methods of learning and his needs in our social order.

Efforts of science teachers to expand and modify their present courses in science were evidenced by work being done in various parts of our country.¹ This shows that science instructors were aware of the need for an expanded and more satisfactory program. Different interests and varied abilities are being provided for in having the pupils engage in individual and group projects. The approaches to teaching the scientific laws and principles are being shifted. More emphasis is being placed upon inductive approaches. Many

1. "Physical Science Today--A Symposium", The Science Teacher, XVIII, (February through December 1951), Pp. 13-21.

teachers are attempting to find a suitable content for a physical science course in the eleventh and twelfth grades. There was some evidence that some schools have dropped the requirement of general science as a course in the ninth grade since they felt that it was duplicating science courses as they are now being taught in the seventh and eighth grades. Some schools are now using a fused physical science course in the tenth, eleventh, or twelfth grade. Some schools are allowing the pupils who enroll in this fused course, to later take the conventional course in physics, chemistry, or both. Many of the schools in the South are making it a requirement that high school students must complete one year each of a biological and physical science. General science in the ninth grade is not being counted as a physical science course for purposes of meeting the graduation requirements. Also, the studies show that there was no text book limited in content to just physics and chemistry. The physical science courses in high school were found to be composed of principles found in physics, chemistry, geology, astronomy, meteorology, and various consumer aspects.

Few attempts had been made to fuse physics and chemistry and evaluate the results. Shailer Peterson², in a study, fused the two courses with the intent of comparing the achievement of such groups with control groups. His study appeared

2. Peterson, Shailer, "The Evaluation of A One-Year Course, The Fusion of Physics and Chemistry, With Other Physical Science Courses", Science Education, XXIX, (December 1945), Pp. 255-264.

to be thoroughly and expertly done. His work consisted essentially of selecting a suitable content from both physics and chemistry texts, administering the course over a period of several years, revising the content and methods of teaching, and comparing the achievement of this group with the groups enrolled in the conventional chemistry, physics, and senior science courses being offered. By equating his groups as to intelligence quotient and chronological age, he was able to arrive at some definite conclusions. The following are quotations from Peterson's conclusions:

This experiment demonstrated the practicality of developing a one-year physical science course that included a large proportion of the facts, concepts, and principles commonly found in most traditional chemistry and physics courses. It was also found possible to construct a single measuring instrument that is useful for courses offering either chemistry, physics, or both.

Under controlled conditions in which intelligence quotient and chronological age were statistically equated, the physical science mean scores of students who had had one year of the Fusion of Physics and Chemistry were significantly higher than that of students who had had either 1. one year of traditional Physics, 2. one year of traditional Chemistry, 3. one year of Senior Science, or 4. one year of traditional Physics plus one year of traditional Chemistry. The general conclusion can also be drawn that the Fusion group does as well or better than the other groups on most of those objectives represented by part-scores on the comprehensive examination. From the areas of significance, it can be concluded that the superior achievement of students in the Fusion course was not narrowly limited by the factor of IQ. Moreover, it would seem that all students who are no older than those ordinarily enrolled as juniors and seniors in high school should profit more from the Fusion course than from the conventional courses.(...)

It was demonstrated by the groups who returned the following year to study more physical science that only a small amount of the information and

skill acquired in the Fusion class was lost or forgotten during the summer vacation.

In final summary, the author concludes that the Fusion of Physics and Chemistry has much to commend it as a substitute for the traditional one-year courses of Physics, Chemistry, or Senior Science and that the Fusion course should even be considered a possible substitute for two years of the usual Physics and Chemistry.

Other studies have been made in this field. Heidel³ studied the achievements of classes in conventional physics and a generalized high school senior science course in which the content was taken from physics and chemistry and taught with consumer aspects. His conclusions were not as conclusive as those of Peterson, but were noteworthy. The following quotation is from his conclusions:

The generalized high school senior science course and the conventional high school physics course are both effective in bringing out significant gains in knowledge of scientific facts and information of a general nature. Gains were greater in the conventional high school physics course, probably because of the greater ability of the students enrolled in this type of course.

The generalized high school senior science course did not prove effective in bringing about significant gains in knowledge of specific physics materials while the conventional high school physics course proved effective in bringing about highly significant gains in knowledge and understanding of physics materials.

Although significant differences existed between the students of the generalized high school senior science course and the students of the conventional high school physics course on scientific attitudes as measured by Noll's Attitudes Test, neither the generalized high

3. Heidel, R.H., "A Comparison of the Outcomes of Instruction of the Conventional High School Physics Course and the Generalized High School Senior Science Course", Science Education, XXXVIII, (March 1944), Pp. 88-89.

school senior science course nor the conventional high school physics course proved effective in bringing about significant change in scientific attitudes.

The generalized high school senior science course proved no less effective than the conventional high school physics course in the teaching of general scientific facts and principles and application of those principles to pupils when inequalities of mental ability and previous achievements were taken into account.

The conventional high school physics course proved definitely superior to the generalized high school senior science course in developing in pupils understanding of specific physics materials as measured by several physics tests even after inequalities of mental ability and previous achievement were taken into consideration.

The generalized high school senior science course proved no more effective than the conventional high school physics course in bringing about the attainment by students of specific consumer outcomes or objectives as measured by several tests after factors of inequalities of mental ability were considered.

Hunter⁴ states in his article:

There is considerable evidence to show that science teachers are becoming awake to the fact that science must be made more vital and more functional if it is to retain its present place in the curriculum, and that they are changing their courses to meet the new demands of the present-day clientele who need to be prepared to meet the new conditions of life.

Much work has been done in school systems to provide courses which will be of more value to the non-college group. Thus, one of the major problems in curriculum development in science is the provision for

4. Hunter, George W., "Six Hundred Teachers Look at Science Trends", Science Education, XXXVIII, (February 1944), Pp. 14-25.

some type of physical science course for pupils in the eleventh and twelfth grades which will not replace present classes in physics and chemistry, but will give those pupils who do not take any physical science beyond the tenth grade, a science course which will be beneficial and enlightening.⁵ This does not imply that we are to offer a course which high-school pupils can complete with but a minimum of effort and understanding. It must be a course which tests the ability of the best, and be helpful and meaningful to all. R. W. Lefler states:⁶

Physical science at the general education level should, along with biology, be a requirement for every student. Living today, particularly living in a state of partial or total mobilization, is too dependent on scientific and technological development for our citizen to go on without understanding the basic principles of both the biological and physical sciences.

A study of the physical science texts⁷ now being used in place of the traditional physics and chemistry texts showed that they were not uniform in either the fields of physical science covered nor the principles in the various fields which they included. Obviously, enough work has

5. "Science Education in American Schools", Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, 1947, P. 139.

6. Lefler, R.W., "A Science Program for the Present Crisis", The Clearing House, XXV, (February 1951), P. 347.

7. Blanchet, W.W., "Subject-Matter Topics Contained in Textbooks For Use in Survey Courses in the Natural Sciences", Science Education, XXXII, (February 1948), P. 93.

not been done to determine just exactly what subjects should be included in the fused course, nor the principles which should be included. There are likely to be so many fields included in the fused course that the principles which are needed from each field cannot be adequately covered nor explained. Many of these physical-science courses have fallen into the so-called "consumer" science category with emphasis upon the acquisition of subject matter rather than the understanding of basic principles. In 1943, Wise⁸ made a study of a number of research reports which dealt with the most important concepts which should be included in a fused physical science course. His study showed the lack of uniformity in emphasis upon content to be covered in such a fused course.

Methods of teaching the various courses now being called "physical science" in the secondary schools vary a great deal, and no satisfactory method has been developed which will adapt our present laboratory methods entirely to the fused courses.⁹

In an attempt to cover the field of current research, the writers have found very little, if any, uniformity in the many attempts to find suitable fused physical science courses. However, there is plenty of evidence¹⁰ that the

8. Wise, H.E., "A Synthesis of the Results of Twelve Curricular Studies in the Fields of Science Education", Science Education, XXXVII, (September-October 1943), Pp. 67-76.

9. Symposium, op. cit., p. 92.

10. Hunter, George W., op. cit., p. 13.

school teachers and supervisors feel that the time has come for definite advances in the science curriculum.

In summary, the review of literature showed that work has been done and is being done in reconstructing the science curriculum in the secondary schools. Educators and classroom teachers have modified, expanded, and eliminated features which seemed undesirable and inadequate after a reconsideration of the contemporary needs of the high-school youth. These efforts at reconstruction were prevalent in all parts of the country and as a result, no well-defined pattern for the modification of the curriculum has as yet evolved.

Some studies have been made in the fusing of various physical science courses and evaluations made. Check lists of what should be in a fused physical science course were also being set up by recognized educators in the field of science education. Laboratory procedures and techniques seemed to vary with the teachers and the schools.

Uniformity of purpose and action is still to be agreed upon. The review showed that present textbooks in combined sciences were not satisfactory and a textbook of fused physics and chemistry was not as yet on the market. There was, however, uniformity in the opinion that a change was necessary because the science curriculum of our schools has not kept pace with the needs of our present-day youth in this scientific world.

CHARACTERISTICS OF GROUPS USED IN THE STUDY

Since the writers taught the two classes in the fused course in physics and chemistry (hereafter referred to only as the fused course), and at the same time taught the conventional courses in physics and chemistry, they felt that a clearer understanding of the aforementioned classes would make it easier for the reader to interpret the results.

As has already been stated, all pupils in the tenth grade enroll in biology in the Watertown High School. About thirty-five percent of the pupils in the eleventh grade enroll in chemistry, and these pupils are scholastically in the upper one-third of their class. Over eighty percent of these chemistry students intend to enroll in college upon graduation from high school. The same is also true of the twenty percent of the seniors who enroll in physics.

Those pupils who elected to take the fused course were of the same scholastic classification as the groups which formerly had elected the senior science course which had been offered. No attempt was made to select the pupils who enrolled in the fused course. This group was composed of juniors and seniors who did not plan to attend college, but wanted a science course beyond biology. These pupils were told that they would probably not be denied entrance to a college¹ because they had selected this course in preference to the regular course in either chemistry or

1. "The Acceptability of Physical Science as a College Entrance Unit", Science Education, XXX, (April 1946), Pp. 127-132.

physics. However, they were told that they would not be allowed to enroll in the physics or chemistry classes the following year.

The pupils in the physics, chemistry, and fused course classes had been tested using the New California Short-Form Test of Mental Maturity Advanced '47 S-Form (Appendix F). The writers took the scores in Table I from the cumulative

TABLE I. MENTAL ABILITY SCORES IN TERMS OF I.Q. OF ALL PUPILS WHO PARTICIPATED IN THE TESTING PROGRAM

IQ Score	Total	Chemistry	Physics	Fused
136-139	2	1	1	0
132-135	1	1	0	0
128-131	4	2	2	0
124-127	3	3	0	0
120-123	16	9	6	1
116-119	12	7	5	0
112-115	16	10	2	4
108-111	23	12	6	5
104-107	22	3	11	8
100-103	9	0	3	6
96-99	11	2	0	9
92-95	2	0	0	2
88-91	5	0	0	5
84-87	1	0	0	1
80-83	1	0	0	1
76-79	1	0	0	1
Number	129	50	36	43
Median IQ	109.5	114.7	109.5	101.2
SD	10.08	8.08	8.68	9.08

records of the pupils used in the study. It was interesting to note in the study of these cumulative records that those in the fused group had a general academic achievement record between the letter grades of C and D, while those in chemistry and physics had C or greater, with the majority having B averages.

A study of Table I indicates that the median IQ of all students who participated in the testing program is 109.5. This is slightly higher than the average for all seniors which is 106.5 and also very slightly higher than that of the entire junior class which is 108.1. (The median IQ's of the junior and senior classes are not included in Table I).

The median IQ of the students in the chemistry class, which was composed of twenty-two girls and twenty-eight boys, was 114.7. The above group was composed of juniors with the exception of three senior boys. The median of chemistry group was considerably higher than the median IQ of the fused-course group which was 101.2. The fused-course group was composed of eight girls and thirty-four boys. The median IQ of the physics class, consisting of senior boys, was 109.5. This is still well above the median of the fused-course group. By coincidence, the median IQ of the physics class was the same as that of the three groups combined being compared in the study.

Of the groups, the standard deviation is greatest for the fused-course group. The standard deviation of the entire group is greater than that of any of the other three groups. The reason for this may be accounted for in that the high scores of the physics and chemistry groups are considerably above the high scores of the fused group, and the low scores of the fused group are considerably below the low scores of the better groups.

Since the writers had taught most of the pupils in this study in prior classes, they felt that the fused group

would exhibit marked differences from those who normally enrolled in the conventional physics or chemistry classes in such characteristics as interests, background, mental ability, attitudes, plans, etc. A study of the cumulative records of all the pupils in physics class, chemistry class, and fused group, and an examination of Table I seemed to confirm these beliefs.

CONTENT AND TEACHING PROCEDURE USED IN THE FUSED COURSE OF PHYSICS AND CHEMISTRY

Selecting The Content For Fused Course In Physics and Chemistry

Prior to this study, a course in senior science had been offered in Watertown High School and was taught by one of the writers. As has been stated elsewhere, the course as taught, included parts of many other sciences in addition to a small amount of physics and chemistry, such as botany, zoology, geology, astronomy, physiology, and then used a consumer-aspect approach.

The course seemingly was a general science course all over again, except that there was more reading, only a small amount of mathematical application and no laboratory work. By the very nature of the course, it was impossible to go any deeper into a consideration of scientific principles than the student already had, either from his previous experience in general science or incidental reading. The students' knowledge and experiences were not being sufficiently increased either actually or vicariously.

Since in the opinion of the writers, the needs of the students were not being met, they felt obligated to set up a content for a fused course in physics and chemistry which would generally satisfy an approved list of objectives. It was also felt that this content would have to be taught for at least one year in order to make some type of evaluation of the selected content.

After making a study of a number of viewpoints, it was concluded that the objectives listed by the Committee for the National Society for the Study of Education were as inclusive and as well expressed as could be found.¹ The objectives listed in the above study are as follows:

A. Providing opportunities for growth in the functional understanding of facts.

B. Providing for development of functional concepts.

C. Providing for growth in the functional understanding of principles.

D. Providing opportunity for growth in basic instrumental skills.

E. Providing opportunity for growth of skill in the use of elements of scientific method.

F. Providing for growth in the development of scientific attitudes.

G. Providing for growth in the development of appreciations.

H. Providing for growth in the development of interests.

The selection of a workable outline of content for the fused course required much thoughtful consideration. It was difficult to determine just what principles and concepts should be included since there was such an abundance of material available. However, it was kept in mind that the function of science in a general education is not comparable to specialization, and that the products of our science courses will not generally be research personnel. Such a course should, however, provide an adequate background for those who wish to continue their formal education,

1. "Science Education in American Schools", Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, 1947, p. 142.

or go from high school into technical and semi-technical fields.

Numerous studies have been made to determine just what principles and concepts should be included in high-school courses in chemistry, physics, and physical science. The writers used the surveys of W.W. Blanchet², F.D. Curtis³, and Vaden W. Miles⁴ to check the principles which they thought should be included in a course of fused physics and chemistry. There appeared to be an agreement in these studies as to what principles and concepts should be of major importance for inclusion in these courses. This made it somewhat easier to eliminate certain principles which the writers felt were not necessary to a basic understanding of the fused physics and chemistry course.

In studying the outline of content for the fused course, the reader will notice that it is divided into an introduction and six main units with a time allotment given to each unit. The time allotments vary from one to as many as nine weeks.

The outline contains only the bare essentials as to content with opportunity for the instructor to vary the time considerably. In constructing the outline, where

2. Blanchet, W.W., "Subject-Matter Topics Contained in Textbooks for Use in Survey Courses in the Natural Sciences", Science Education, XXXII, (February 1948), Pp. 88-93.

3. Curtis, F.D., Third Digest of Investigations in the Teaching of Science, p. 143.

4. Miles, Vaden W., "A Determination of Principles and Experiments for An Integrated Physical Science for High Schools", Science Education, XXXIII, (March 1949), Pp. 147-155.

the texts and references contained good instructional materials to use, it was shortened somewhat. At other places where principles were introduced, for which the available texts and references were not very satisfactory, the outline was amplified somewhat. For example, the introductory unit with the time allotment of one week, for which text materials were not very abundant, was made fairly detailed, whereas in Unit IV on Chemical Reactions for which the text material was ample was a one-page outline for eight weeks time. The outline, unit by unit, was duplicated and put in the hands of the pupils.

Course Outline for Fused Physics and Chemistry

Introduction - Time 1 week.

- A. What is science?
 - 1. Classified knowledge of known laws of nature.
 - 2. Physical sciences and biological sciences.
 - a. Branches of science.
 - (1) Physics, chemistry, zoology, botany, geology, etc.
 - 3. Meaning of a scientific law.
 - a. Man-made laws.
 - b. Some common laws of nature easily observed.
 - (1) Gravity, gas expansion, buoyancy, earth's movements, and the same properties of any chemical compound.
- B. Why should we study science?
 - 1. Understanding ourselves and our environment.
 - 2. Develop the ability to reason scientifically.
 - 3. Uses at work and in the home.
 - 4. Relation of science to world affairs.
 - 5. Develop needed skills and attitudes.
 - 6. Advancement of science for human welfare.
 - 7. Appreciation and respect for the men and their work in science.
 - 8. Acquire habits of accuracy, honest, etc.
 - 9. Promote interests.
- C. What have other nations contributed in the study of science?
 - 1. Marconi, Lavoisier, Oersted, Mendelejeff, Faraday, etc.
 - 2. Need for cooperation among the world's scientists.
- D. What is the nature of the Scientific Method?
 - 1. Recognized steps in the scientific procedure of problem solving.
 - a. Recognizing that a problem exists.
 - b. Collecting facts and information.
 - c. Organizing and classifying facts.
 - d. Preparation of a tentative explanation.
 - e. Testing and checking explanation.
 - 2. Scientific method versus other methods in problem solving.
 - a. Trial and error, guessing, superstition, etc.
 - 3. What are desirable scientific attitudes?
 - a. Accuracy, honesty, open-mindedness, recognizing cause and effect relationship, considering all factors in a problem, cautiously drawing conclusions, etc.
 - b. Accurate observation.
 - c. Value of the scientific experiment, and the nature of the scientific experiment.

Unit I. The Nature of Matter - Time 5 weeks.

- A. How and why we measure.
 1. History of measurement.
 2. The need of the metric system in science.
 3. The uses of the English system of measurement.
 4. Conversion of units within a system, and conversion of units between systems.
- B. General properties of matter.
 1. What is matter?
 2. The states of matter.
 3. How does the modern concept of matter differ or agree with Dalton's concept?
 4. How do scientists visualize the atom?
 5. What are metals and non-metals?
 6. To learn about the reactions of atoms and why we must know about valence.
 7. Symbols and formulas.
 8. How to identify and name chemical compounds.
 - a. What are radicals?
 9. Definitions of:
 - a. Volume, mass, weight, porosity, inertia, impenetrability, etc.
- C. Concepts in the study of matter.
 1. What are elements, compounds, and mixtures?
 2. The importance of the law of definite proportions.
 3. More about atoms, molecules, and ions.
 - a. Electrovalent, covalent, and coordinate bonding.
 - b. Atomic and molecular weights.
 - c. Empirical and structural formulas.
 4. How do we explain the behavior of gases and liquids?
 - a. Brownian movement, diffusion, osmosis, capillary action, vapor pressure, surface tension, adhesion, and cohesion.
 5. What is the difference between a chemical change and a physical change?
 - a. The difference between chemical properties and physical properties.
 - b. Demonstrate physical and chemical changes.
 6. How does the chemist indicate a compound, and how does he show or indicate reactions?
- D. Special properties of matter.
 1. Tenacity, ductility, malleability, brittleness, hardness, and Hooke's law.
- E. Why do some objects float and others sink?
 1. The meaning of density and its importance.
 2. Comparing the weights of different matter to the weight of an equal volume of water.
 3. Demonstrate density, specific gravity by pupils.
 4. Problems involving density and specific gravity.

Unit II. Heat Energy - Time 9 weeks.

A. What is energy?

1. Kinds and forms of energy.

B. Heat energy.

1. How is heat produced by chemical means?
 - a. Oxidation, combustion, spontaneous combustion, rusting, decay, etc.
 - b. Endothermic and exothermic reactions.
 - c. Explanation of burning; Priestley's and Lavoisier's experiments.
 - d. Demonstrate preparation and properties of oxygen. Define oxides, ozone, allotropic forms, etc.
 - e. Common fuels and their composition.
2. How do we control heat?
 - a. Common stoves and furnaces.
 - b. Effect of increased surface areas in burning.
 - c. Kindling temperature.
 - d. The Bunsen burner.
3. How do we measure temperature and heat?
 - a. The degree of heat, Fahrenheit, Centigrade and Absolute (Kelvin).
 - b. The calorie and the B.T.U.
 - c. Temperature conversions.

C. What is the effect of heat upon solids, liquids, and gases?

1. Charles' Law, Boyle's Law, and the common gas laws.
 - a. Problems involving volume, temperature and pressure changes.
2. Expansion of solids.
 - a. Demonstrate compound bar, expansion of solids, thermostat, and the thermometer.
 - b. Demonstrate and calculate the coefficient of linear expansion.
 - c. Problems involving linear expansion, and stating of common examples.
3. How do we make use of the expansion of liquids?
 - a. Liquid thermometer.
 - b. Expansion tanks, hot water systems.

D. How is heat transferred.

1. Convection.
 - a. Winds, currents, etc.
 - b. Ventilation.
2. Conduction.
 - a. Thermal conductivity.
3. Radiation and reflection.
 - a. Surfaces.

Unit II. (Continued).

- E. What happens when two or more substances with different temperatures are combined?
 - 1. Simple mixture problems.
 - 2. Specific heat and complex mixing.
 - 3. Heat of fusion and vaporization.
 - 4. Refrigeration, evaporation, dew, rain, fog, humidity, etc.

- F. What relation exists between heat and work?
 - 1. Compression, percussion, friction.
 - 2. Mechanical equivalent of heat.
 - 3. The internal and external combustion engines.
 - 4. Trapping the sun's energy.

Unit III. Forces, Work, and Machines - Time 5 weeks.

- A. What are the forms and causes of forces?
 - 1. Definition of force, and pressure.
 - a. Units-gravitational, absolute.
 - 2. Pressure of liquids.
 - a. Pascal's law.
 - b. Hydraulic press and applications.
 - 3. Buoyancy of liquids.
 - a. Archimedes' principle and applications.
 - 4. Pressure of gases.
 - a. Atmospheric pressure.
 - b. Buoyancy of gases.
 - c. Boyle's law.
 - d. Lift pump, force pump, siphon, and pneumatic machines.
 - 5. Composition and resolution of forces.
 - a. What is a vector?
 - b. Graphing forces, parallel and at angles.
 - c. Elements of navigation.
 - 6. Principle of moments.
 - a. Center of gravity.
 - b. Turning effect.
 - c. Stability.
 - 7. Motion.
 - a. Uniform and accelerated.
 - b. Newton's laws of motion.
 - c. The pendulum.
 - d. Effect of friction.
- B. How do we define work?
 - 1. Measurement.
 - 2. Potential and kinetic energy.
 - 3. Power.
- C. How simple machines increase our force.
 - 1. The six common types of machines.
 - 2. The meaning of mechanical advantage.
 - 3. Efficiency of machines.
 - 4. Compound machines, gears, fluid drive, clutch.
- D. Aerodynamics.
 - 1. Why does an airplane fly?

Unit IV. Chemical Reactions - Time 8 weeks.

- A. What are the types of reactions?
 - 1. Direct combination.
 - a. Common examples.
 - (1) Burning of fuels, corrosion, etc.
 - b. Heats of formation.
 - (1) Value in predicting stability of compounds.
 - 2. Simple decomposition.
 - 3. Single replacement.
 - a. Activity series of metals and non-metals.
 - 4. Double replacement, or new pairings of ions.
 - a. Solubility, volatility, and non-ionization.
 - 5. Reversible reactions and dynamic equilibrium.
 - 6. Law of mass action and application.
 - 7. Hydrolysis.
- B. What is the nature of some common acids?
 - 1. Hydrochloric, sulfuric, and nitric.
 - 2. Chemical properties and common reactions of acids.
 - 3. Commercial preparation and uses.
 - 4. Dehydrating and oxidizing properties of some acids.
- C. What is the nature of some common bases?
 - 1. Caustic soda, caustic potash, slaked lime.
 - 2. Properties of bases, and common reactions.
 - 3. Protolysis.
 - 4. Neutralization.
 - 5. Preparation and uses of.
- D. Common salts and their formation.
 - 1. What is a salt?
 - 2. Common salts and their uses.
 - 3. General methods for preparing and purifying.
- E. Problems in equation solving.
 - 1. Writing and understanding the chemical equation.
 - 2. Balancing the equation.
 - a. Simple equations and oxidation-reduction.
 - 3. Value of writing correct equations.
 - 4. Problems derived from equations.
 - a. Weight-weight.
 - b. Volume-volume.
 - c. Weight-volume.
 - 5. Percentage composition.

Unit V. Sound and Light - Time 2 weeks.

A. Sound.

1. What causes sound?
2. Characteristics of sound.
 - a. Loudness.
 - b. Pitch.
 - c. Quality.
3. Resonance and interference.
 - a. How can a given sound be made louder?
 - b. How can two or more sounds produce an unpleasant sensation?
4. Musical instruments.
 - a. What physical characteristics must a string have to produce a variety of pitches?

B. Light.

1. What is light?
 - a. Type of wave.
 - b. Velocity and calculations of.
2. What should we know about lighting?
 - a. Inverse-square law.
 - b. Luminous efficiency of lamps.
 - c. Definitions of foot candle, candle power, and lumen.
 - d. Proper light for reading, sewing, etc.
3. How does light reflect from different kinds of surfaces?
 - a. Plane, convex, concave mirrors.
 - b. Demonstrations of mirrors.
4. How do light rays bend as they pass from one substance to another?
 - a. Refraction in plane, convex, concave lenses.
 - b. Optical instruments.
 - c. Diagrams, problems, demonstrations.
5. Color spectra, and polarization.
 - a. Why can we see different colors in white light?
 - b. How can elements be identified from a spectrum?
 - c. Nature of polarized light.
 - (1) How is this used in chemistry?

Unit VI. Magnetism and Electricity - Time 6 weeks.

A. Magnetism.

1. History of magnetism - Chinese, Columbus, etc.
2. How do magnets behave?
3. What is our explanation of magnetism?
4. The earth as a magnet.
 - a. Use in navigation.

B. Static electricity.

1. The electrical nature of matter.
 - a. Electrons, protons, etc.
2. Behavior of static charges similar to magnetism.
3. How can static charges be produced?
4. What is a capacitor?
 - a. Uses.

C. Current electricity.

1. Chemical nature of primary cell.
2. Electrical units.
 - a. Ohm's law.
 - b. Voltage drop.
3. Series and parallel wiring.
 - a. Danger or overloading.
 - b. Elementary wiring.
4. When to hook up cells in series or parallel?
5. Electrical energy and power.
 - a. Reading the watt meter.
 - b. Determine cost of light bill.

D. What are the effects of the electric current?

1. Heating effects.
 - a. Coils and fuses.
2. Chemical effects.
 - a. How can we produce oxygen, hydrogen?
 - b. How does industry use electrolysis, and electroplating?
 - c. How does a storage battery work?
 - (1) How to care for it.
3. Magnetic effect of an electric current.
 - a. Making an electromagnet.
 - b. How does an electric bell work?
 - c. Electrical instruments.
 - (1) Where and how to use.
 - d. How to make a motor.
4. Electromagnetic induction.
 - a. How can we produce electricity?
 - (1) A.C., D.C.
 - b. What is back electromotive force?
 - c. The induction coil.
 - d. Transformer.
 - (1) Uses, efficiency.
 - e. Telephone circuit.

Unit VI. (Continued).

- (1) How does a carbon microphone work?
- (2) How can we get by with one wire between stations?

5. Electronics.

- a. How does a radio tube work?
- b. What are the parts of a radio, and what are their functions?

Comments On The Outline

With no available textbook, it seemed of vital importance that the students have an outline of the unit at the beginning of each unit. It was good to have the student visualize the skeleton outline and have it take shape as progress was made.

The reader must recognize the fact that the time necessary for developing and completing a unit was not in direct proportion to the length of the outline as presented by the writers.

The outline in general follows a sequence of concepts which is readily adapted to any text a teacher may desire to use as reference. Since the outline consists mainly of topics, it is implied that the teacher should help the pupils state in their own words the scientific laws, principles and concepts.

In order to be sure that the outlined contents of a unit were fully developed, the teacher had to be satisfied that the pupil apply these principles in written problems, in general discussion, and their everyday activities.

Teaching Procedures Employed In Course Of Fused Physics and Chemistry

The teaching procedures, as reported in this section of the study, are reported only to show how the writers taught the content of the fused course for a period of one year. The methods used in teaching the fused course were not considered by the writers as the "one best way", and no doubt reflect the experiences of the writers who have taught the various high-school sciences a number of years. Teaching procedures must be adaptable and flexible to fit various teaching situations. The following techniques, for the most part, were found satisfactory under the conditions as found in the Watertown High School.

The pupils who enrolled in the fused course were placed in two classes of twenty-six and seventeen members. Conflicts in scheduling prevented the classes from being evenly divided. The writers, one a physics teacher, and the other a chemistry teacher, each taught one of the classes. This condition served to balance the objectives and content which were selected from the field of physics and that of chemistry.

The writers were unable to locate a textbook which included the content for a fused course in physics and chemistry. Therefore, each pupil in the fused course was encouraged, but not required, to purchase two handbooks, one, "Basic Units In Physics", and the other, "Basic Units In Chemistry", (listed in full in Appendix A). About ninety percent of the pupils purchased these handbooks.

For those who did not purchase the handbooks, the handbooks were made available as reference books. These handbooks facilitated the reference work for the pupils, and also proved an aid in making assignments. Many of the questions, problems, and explanations were taken from these handbooks. Reference texts (titles listed in Appendix A) in chemistry and physics were made available in the classroom and the school library. The reference texts were used mainly during the supervised study, or before and after regular class periods.

A list of experiments was prepared in advance of each unit (Appendix C). The experiments were in most cases performed by the pupils as demonstrations. In a few instances the experiments were demonstrated by the teacher when it was felt that a consideration of factors involving such procedure was desirable. No individual laboratory work was done.¹ Experiments were selected by the teachers and assigned to two pupils a few days in advance of the demonstration. These pupils were given laboratory manuals in order to study the procedure, gather the necessary equipment, rehearse the demonstration, perform the experiment, and explain or answer questions directed from the class. There are always a certain number of experiments which may be classed as "emergency". By this, the writers refer to such demonstrations as are necessary to enlarge upon a principle or concept to provide better and more thorough understanding.

1. Cunningham, H.A., "Laboratory Demonstration Versus Individual Laboratory Method in Science, A Summary", Science Education, XXX, (March 1946), Pp. 78-79.

The equipment necessary for these experiments or demonstrations was not as extensive as that which is required in the conventional courses of physics or chemistry, since the more complex experiments were avoided. In advance of the classroom demonstration, the pupils placed the equipment on a portable table which was wheeled into the classroom at the beginning of the class period. This saved time in collecting the materials or carrying them into the classroom when several trips were necessary. The classroom was equipped with a demonstration table equipped with water, drain, electrical outlets, and source of propane gas. Classes in the fused course, conventional physics and conventional chemistry were taught in the same room, however the conventional physics and chemistry classes had separate laboratories for individual experiments.

The class period in the fused course was utilized in presenting and developing the units of work. The characteristics of the word "unit" are those as suggested by J. Minor Gwynn.² The basic principles underlying the methods employed in developing the units were selected from a list as accepted by A.A. Douglass.³ These principles are:

1. The student must have a conscious goal toward which to work.
2. Interest conditions learning.
3. Concrete experiences are essential. Some kind of adjustment is necessary on the part of the pupil.

2. Gwynn, J. Minor, Curriculum Principles and Social Trends, Pp. 176-177.

3. Douglass, A.A., Modern Secondary Education, Pp. 630-636.

4. Some kind of plan must be evolved in order to carry out any given learning unit.
5. The procedure must be flexible.
6. Results must in some way be evaluated.

The teaching techniques varied with the content or material to be learned. A variety of supplementary materials was used to make the concept or principle more meaningful. For example, in teaching the properties of matter, film strips were employed by the writers to substantiate reference definitions and chalk-board discussions. In the discussion of atomic structure, a motion picture dealing with behavior of electrons was shown to supplement reference work, charts, and models. Other supplementary materials included the use of current periodicals, graphs, and special reports to be given during class discussion period.

Since each pupil had an outline of the unit being studied, each section of the unit was introduced by discussing the section in terms of the concepts already established in the pupils' past experiences. After these concepts were organized, the students were then led to see that they had to do some research and study on their own. Supervised study was utilized as the occasion demanded it. During supervised study, the students asked questions privately and received help from the teacher. When an out-of-class study or assignment was made, an attempt was made to give the students a clear understanding of what to look for. Finding the material in the library was left, in most cases, to the discretion of the student, and he was more or less on his own as to the amount of work he did out of class.

The fused group did not have the intellectual nor mathematical background to be able to do the same quality of work as the students in the conventional physics or chemistry classes. However, a scientific concept can usually be comprehended more fully by having it verified by means of basic arithmetic. Simple problems always helped to establish a basic concept. The writers used problems very freely, but limited the type of problem to simple algebraic equations involving direct and indirect variations.

Another technique employed was one of worksheets. These consisted of questions or problems (example shown in Appendix B) which could be looked up in the reference books, or problems which could be reasoned out. These generally were excellent for group discussion, where the teacher remained in the background and guided the discussion.

The time and effort in the fused course was utilized mainly in developing the basic concepts of the course. Obviously, the time was not available in the fused course to develop as many principles and concepts as is done in the regular physics or chemistry classes.

Since each pupil kept a notebook, it was used for the following purposes:

1. To keep a record of daily assignments, unit assignments, and worksheets.
2. To maintain an account of classroom discussions.
3. To record basic concepts shown in a demonstration.
4. To keep notes on references studied.
5. For study and review.
6. When fully developed, it became their textbook.

After regular class periods were completed, the writers

got together and discussed and reviewed the procedures for advanced work. This was done in order to prevent one of the writers from putting too much time and emphasis upon that phase of the fused course which paralleled his major teaching field of either physics or chemistry. The same outline content, problems, experiments, and demonstrations were employed in both sections of the fused course.

Since the pupils who enrolled in the fused course did not have the background to do much abstract reasoning, every attempt was made to make examples concrete. This was accomplished by the use of the supplementary materials already listed, but by far the greatest amount was done in using the chalk board for detailed drawings, rough sketches, and diagrams.

The writers found that some principles developed rather easily and then again, the opposite was true. This was often true because of the past experiences of the students. In the same sense, the rate of development varied within the group. It was also felt that versatility was vital in the efficiency of teaching the fused course. It was concluded that in the fused course, the teacher must be constantly aware of individual differences and a conscientious effort must be made to meet the needs and interests of the students.

TESTING AND TEST RESULTS

Testing Used As Part of Teaching Procedure

In teaching the fused course, the writers cooperatively prepared and utilized a variety of tests. Daily and weekly tests were given to make a check upon comprehension and problem solving. Unit Tests were used to evaluate the over-all understanding, retention, and integration of the unit itself. Six-weeks tests were employed mainly for the assignment of class marks. A final examination was also constructed for the fused course. This final examination was used for assigning class marks and was also used to compare the ranks obtained on this test with the United States Armed Forces Institute Test in Senior Science which was also given to the fused group. The USAFI Test in Senior Science was also given to the classes in conventional physics and chemistry to study the achievement of these classes in the USAFI Test with the achievement which was made on the same test by those in the fused course.

The mental abilities of the students in the fused course were already noted. This information proved helpful in that it gave an indication, more or less, of what to expect as far as achievement was concerned. By using a variety of teaching techniques and allowing a maximum of self-expression, it was felt that the pupils in the fused course did the best they could in the testing used in the study.

Tests, prepared by the writers, were given every few days or at the end of the week in order to determine if the pupils were grasping the meanings of the concepts under consideration. These tests were highly objective since the time element in teaching this fused course did not allow much time to be taken from the class period in giving the tests. The items on these tests were mainly the solving of simple problems, drawing diagrams, explaining of concepts, answering completion questions, or providing the solution to thought questions. These tests made it possible to detect the lack of understanding on the part of the pupils of basic concepts, and thus made it possible to clear up any misunderstanding before proceeding into work which is normally based upon that which precedes it.

Evaluation of the pupils' progress was made at the completion of each unit, (example shown in Appendix D). The items of these tests consisted of: (a) completion, (b) multiple-choice, (c) matching, (d) true-false statements, and (e) problem solving. The types chosen were determined by the nature of the material over which the students were being tested, and the time available for giving the examination. These unit tests made evident the degree of attainment in achievement of the pupils in the fused course. They also aided the writers in checking the teaching methods being employed. If the end of a six weeks period closely approached the end of a unit, the unit test was used as the six-weeks test for the assign-

ment of class marks as well as the purposes mentioned above.

The final test in the fused course (shown in Appendix E) was jointly constructed by the writers. The test was highly objective containing one hundred seventy items. The pupils were allowed ninety minutes for the test, dividing their time equally between the two parts of the test. The test was lengthy and some parts difficult. The pupils were urged to answer those questions which they could answer readily and then spend time on the more difficult questions. The distribution of scores as shown in Table II shows that the

TABLE II. SCORES MADE BY PUPILS IN FUSED COURSE
IN FINAL EXAMINATION

Scores	Frequency	Scores	Frequency
130-136	1	74-80	4
123-129	0	67-73	3
116-122	0	60-66	6
109-115	0	53-59	8
102-108	0	46-52	3
95-101	1	39-45	8
88-94	4	32-38	3
81-87	0		
		Total	41*

scores are skewed to the right. This may be due to the distribution of scholastic ability, or the test was too lengthy, or the test items were too difficult. The mean score was 61.6 and the median 58.2. Since the standard deviation was 20.3 it would indicate the rather high variability of achievement of the pupils in the fused course. The items which were included in the final examination as prepared by the writers varied a great deal

* Two pupils were unable to take the final examination.

in degree of difficulty. Problem solving using mathematics to derive an answer proved too difficult for the average pupil in the fused group.

Testing Used For Comparative Purposes

The writers were interested in how the classes in the fused course compared with the classes in conventional physics and chemistry in achievement in understanding basic principles and concepts in the field of physics and chemistry. Since they felt that the final test in the fused course which they prepared was not standardized it did not appear practicable to give this test to the conventional physics and chemistry classes for comparative purposes. Also, the time element prevented such a procedure as the conventional classes were required to write standardized examinations in their respective fields.

To compare achievement between the classes in the fused course and the conventional classes in physics and chemistry, the writers, with the assistance of the high-school principal, studied several tests and eventually selected the United States Armed Forces Institute Test in Senior Science (shown in Appendix G) because it was the only test found, which more than any other, included fundamentally the concepts and principles in physics and chemistry. This was not a time-test. It was designed to measure primarily the achievement and mastery of scientific principles and their applications. This test was chosen, too, rather than

use our own test, to eliminate bias, familiar wording, or other factors which might enter in. It was not an ideal situation, but it was as good as could be had with the given circumstances.

The two tests used were analyzed item by item to determine the real composition of the tests in terms of science areas. The results of this analysis are shown in Table III. Considering the USAFI Test, it was found that

TABLE III. ANALYSIS OF THE USAFI TEST IN SENIOR
SCIENCE AND WRITERS' FINAL EXAMINATION
AS TO AREA OF QUESTIONS

Scientific Field	USAFI	FINAL
Physics	69	80
Chemistry	30	90
Biology	7	0
Astronomy	3	0
Application of Scientific Attitudes	30	0
Total	139	170

there were sixty-nine physics questions, thirty chemistry questions, seven biology questions and three astronomy questions. In addition there were thirty questions dealing with the application of scientific attitudes. The writers used all the questions in scoring the tests for comparative purposes. In the final test there were eighty physics questions and ninety chemistry questions. The one hundred thirty-nine questions in the USAFI Test were all of the multiple-choice type (Appendix G). Questions involving mathematical computation in both physics and chemistry were scattered throughout the test. Diagrams

were also used in seventeen of the questions.

In the final test (Appendix E), there was a variety of questions. In the chemistry section there were twenty-five true-false statements, twenty multiple-choice, fifteen matching, twenty-five completion and five computations. In the physics section there were sixty completion and twenty problems which required basic arithmetic computation. The reader may wonder why there are more chemistry questions than physics questions. However, one should note that the physics questions included problems which took considerably more time than the true-false questions. The ninety minutes allowed for the test were equally divided between the two sections of the final test.

The USAFI Test in Senior Science was given to the two classes in the fused course, two classes in conventional chemistry, and one class in conventional physics. There was no time limit to the test, and the pupils were allowed to stop whenever they were either finished or had answered all the questions possible. The students were urged to take their time and do their best.

The USAFI Test contained a section of thirty questions dealing with the application of scientific attitudes. The computed medians of scores in this section for the groups tested are as follows: (a) those having had both physics and chemistry, 17; (b) those having had chemistry only, 15; and (c) those having fused course, 13. The variation in the ability to apply scientific attitudes is probably due both to differences in past experiences and in mental ability.

Table IV reveals the distribution of scores of the USAFI Test in Senior Science made by the students who had taken the fused course, those who had had but one year of chemistry, those who had but one year of physics, and those who had had a year each of physics and chemistry. It also

TABLE IV. USAFI TEST SCORES OF ALL PUPILS WHO PARTICIPATED IN THE TESTING PROGRAM

Score	Physics only	Physics & Chemistry Chemistry	Chemistry only	Fused	Total
115-119	0	1	0	0	1
110-114	0	1	1	0	2
105-109	1	0	1	0	2
100-104	0	1	0	0	1
95-99	2	3	0	0	5
90-94	2	3	1	1	7
85-89	1	2	3	0	6
80-84	0	5	4	0	9
75-79	1	3	2	3	9
70-74	1	2	8	6	17
65-69	1	1	5	3	10
60-64	1	2	8	5	16
55-59	1	0	7	9	17
50-54	0	1	5	4	10
45-49	0	0	1	7	8
40-44	0	0	1	4	5
35-39	0	0	0	1	1
Total	11	25	47	43	126
Median	87.5	83	66	58.5	67.5

shows total scores of all combined. Since a few seniors took physics but did not take chemistry, and also a few seniors taking both physics and chemistry at the same time, the totals in Table IV do not agree with those in Table I. The medians appear to be fairly consistent in view of the consideration of the influencing factors of mental ability and previous experience or training in science. The median for those having chemistry only is more than twenty

points lower than those having had only physics, and seventeen points lower than those who had both chemistry and physics. The median score for the fused group is the lowest of the medians for all groups studied. The low median for the chemistry group might be expected since they had not taken a course in physics, and an analysis of test items shown in Table III indicates that the USAFI Test contained over twice as many physics items as chemistry items. The low median for the fused group probably reflects the lack of previous experiences in science and lower mental abilities. One would expect the median for the group which had had both physics and chemistry to be rather high, but it is somewhat more difficult to account for the fact that those having had physics only had a higher median score than any of the other groups. However, the following factors may have influenced the median of the physics-only group: (a) The median IQ of the eleven physics students was 115; (b) Of the 132 items in the USAFI Test, only 30 items pertained directly to chemistry; and (c) There is a certain amount of chemistry taught in any physics course.

The writers had no means of comparing the scores made by the pupils in the testing program with any national or local norms, since none had been established. A statistical treatment of the scores was given only a minor consideration, as it was realized that to give a truly meaningful evaluation, the study would take several years. Other factors which tended to make exact interpretation

difficult were the small number of pupils in each group, and the wide variation in mental ability between the groupings.

When considering the relative percentages of each group in the upper one-half in ability and the upper one-half in test scores on the USAFI Test, a few comparisons were made. Those having had chemistry only, had 85% of the group in the upper one-half of the IQ's for all groups, but had only 47% of the test scores in the upper one-half of the scores for all groups. On the same basis, physics only, had 55% above the median in ability, and 73% above the median in achievement. The group having had both chemistry and physics had 43% above the median in ability and 79% above the median in achievement. Since the fused group had 19% above the median in ability and 24% above the median in achievement, one might consider that they did relatively well. If one considered that the pupils in physics and chemistry formed a select group, then on the same basis by combining the physics only, chemistry only, and both chemistry and physics, we find that the select group has 67% above the median in ability and 60% above the median in achievement.

The reader might at this point conclude that the writers' study failed to uphold the findings of Peterson's study in which he showed that those in fused physics and chemistry did better than the other groups in his comparison; namely, chemistry only, physics only, both physics and chemistry, and senior science. Recalling that his

study used equated groups of high mental ability and that his results were obtained over a period of several years, will enable one to compare his study with that of the writers. It was not the purpose of this study to show that the achievement which they could expect to get from the group in the fused course would excel that made by the other groups. This might have been possible if the groups had had similar backgrounds in science training, and similar mental abilities. However, when Heidel studied the achievements of classes in conventional physics and a generalized high school senior science course, in which the content was taken from physics and chemistry and taught with consumer aspects, he found that the conventional physics course proved more effective in bringing about highly significant gains in knowledge and understanding of physics principles. The writers felt that they were not justified in comparing their study of a fused course, taught without consumer aspects, to that of Heidel. To obtain a valid comparison of the fused group with the other groups, a refined testing procedure would have been required to measure outcomes of education other than the acquisition of subject matter. This was beyond the scope of this study.

To obtain a clearer picture of the results made by the fused group in comparison with the other groups being compared, the scores made on the USAFI Test and the IQ's of the pupils were placed upon a scattergram. The scattergram also makes it easier to visualize the previous

discussion concerning relative achievements. Figure 1 shows that approximately eighty percent of the students fall in

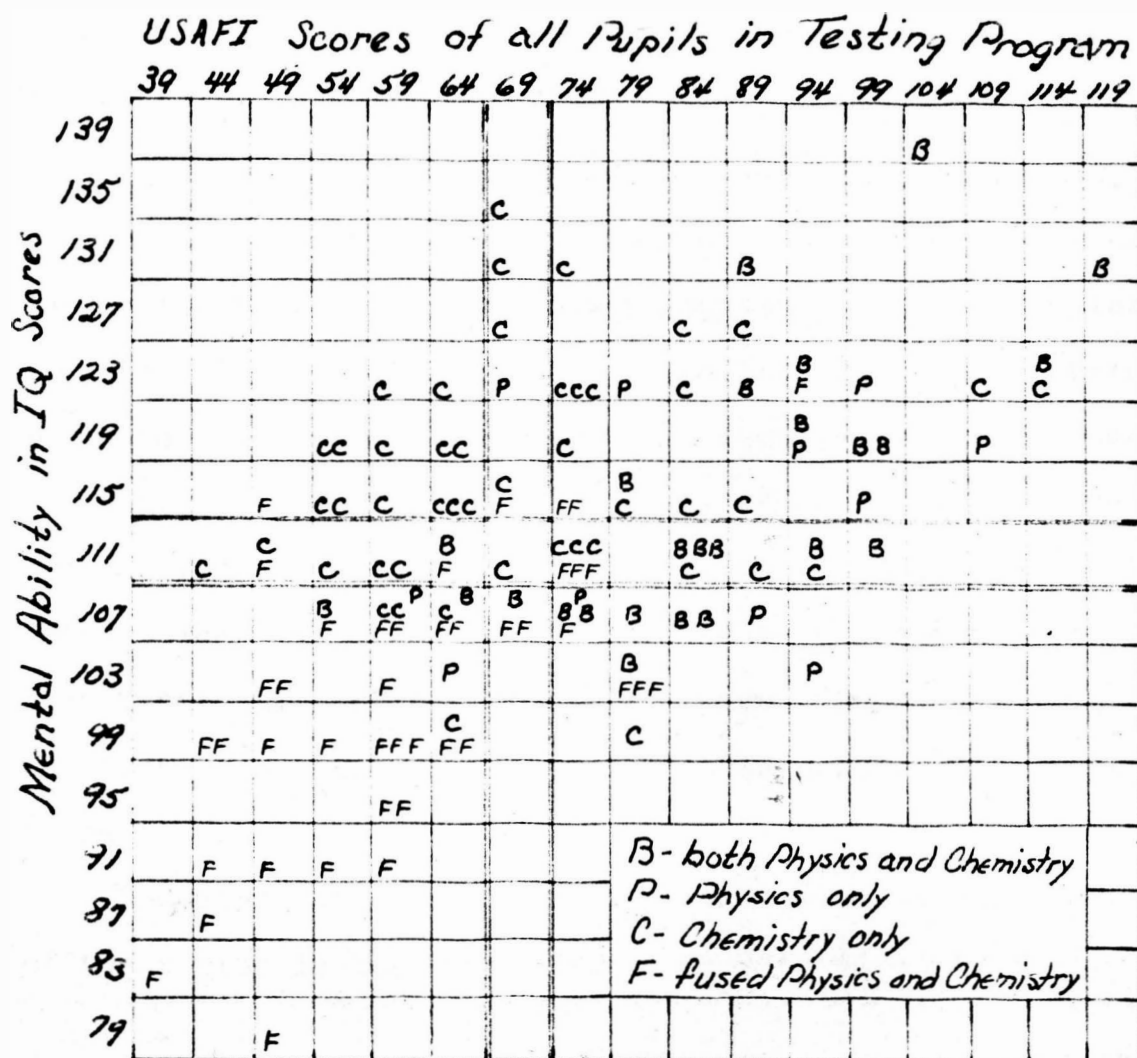


Fig. 1. Scattergram of USAFI Test Scores and Mental Ability Scores of all Pupils Participating

the first (upper right) and third (lower left) quadrants. This might be interpreted as a normal situation. About ten percent are in the second quadrant (upper left) which may be indicative of the fact that they are all under-achievers. This is not necessarily true for two reasons: first, thirteen of the fourteen students are chemistry

students who have not had physics, and secondly, the USAFI Test had sixty-nine physics questions compared to thirty chemistry questions, (refer to Table III). Those in the fourth quadrant (lower right) might be thought of as over-achievers in respect to the test being considered.

Again notice that of eleven physics students in all, six students are in the first quadrant. This may be accounted for by the fact that there are a greater number of physics questions in the USAFI Test and also that there is a certain amount of chemistry being taught in regular physics classes.

About sixty-five percent of the students in the fused physics and chemistry course are in the third quadrant. This is where we might expect them to be when we consider the distribution of IQ's for that group. (One pupil from the fused group is not included in this scattergram since there was no IQ available).

In order to determine whether the relative ranks of the pupils in the fused course as determined by the USAFI Test in Senior Science would be about the same as the ranks for the fused class in the writers' final examination, a rank correlation was computed for the fused class on the two tests. This correlation was $r = .84$ which may possibly indicate that the examination prepared by the writers might be used again as a fair index of achievement in such a fused course in physics and chemistry.

In summary of this section a few factors may be pointed out. Those in the fused course did not do as well in the USAFI Test in Senior Science as the other groups being compared. However, when mental ability and past experience were taken into consideration, their achievement appeared comparable to the other groups.

The items included in the USAFI Test which was used for the comparison had predominately more physics items than chemistry items which would make it possible for those pupils having had physics only, or both physics and chemistry, to do better than those in the fused group.

In the final test which was given only to the fused group, the items in chemistry and physics were fairly well balanced, but since the median number correctly answered was about thirty-three percent, it would indicate that the test was too difficult, or too lengthy.

SUMMARY AND CONCLUSIONS

Recapitulation

Throughout the development of this study, the writers were guided in their procedure by the following questions: Can physics and chemistry be fused into a one-year course for pupils who do not enroll in the conventional physics and chemistry classes? Will such a course be feasible and workable? What content will be included? How will it be taught? How will the laboratory work be handled? Can it be adapted to the interests and ability levels of the pupils? Will the achievement of the pupils in the fused course be comparable to the achievement of the pupils in the other physical science courses?

After considering the major objectives of science teaching in secondary schools, an outline of content for the fused course was selected. This outline was based largely upon previous studies by other authors who sought those major principles and concepts in physics and chemistry deemed essential and desirable for a general education. Each of the writers taught a class in the fused course for a period of one year in the Watertown High School, and an evaluation of the fused course was at least partially made.

The answers to the proposed questions are at least in part to be found in the following section under "conclusions" and "evaluation".

Conclusions and Evaluation

From this study in a fused course in physics and chemistry for Watertown High School, a certain number of conclusions appear to be justified, and some form of evaluation noted.

The study satisfied the premise that physics and chemistry could be fused into a one-year course which possessed coherence, adaptability, and met the objectives of science education for secondary schools.

In actually teaching the fused course, it was found that the various teaching techniques could be easily adapted to the fused course outline without any special training upon the part of the teachers. It also proved that such a course may be taught in the regular classroom used in teaching present classes in physical science.

Classroom demonstrations by the pupils were found to be the most economical from a standpoint of time and equipment. This allowed a greater number of experiments than would have been possible in individualized laboratory experiments.

Teaching the fused course by the methods used, required more preparation and guidance than if a textbook had been available and used. A great deal of resourcefulness on the part of the teacher was required in the organization of materials and the guiding of student activities.

If differences in previous experience and mental ability are not taken into consideration, then one may consider that the achievement made by the fused group was inferior to that made by either those pupils who had taken the course in chemistry, or a year each of physics and of chemistry. However, in those cases where these differences could be considered, the pupils in the fused class did relatively as well as the pupils in the other classes used in the comparison. The comparative test results agreed reasonably well with previous known facts about the pupils, such as past achievement, experiences, and mental ability.

Since such outcomes of education, as habits, skills, attitudes, and ideals are extremely difficult to evaluate, a comprehensive comparison of the groups in the study was not obtained. However, the fused course, as taught, offered opportunities for growth in basic instrumental skills, growth in attitudes and appreciations, and means of developing functional understanding.

No expressed effort was made to secure student reaction to the fused course, but there were a number of favorable comments during the year.

Since the pupils in the fused course were not scholastically as capable as those in physics and chemistry, the teachers found it difficult to demand excellence in performance of organizing reports, explaining demonstrations, and applying mathematics in written problems. It was felt, however, that they made progress in these respects during the year.

Also, from observation, it appeared that some of the pupils in the fused group were very difficult to motivate regardless of the teaching techniques employed.

Recommendations

With a goal in mind, the writers proceeded to set up and teach a fused course in chemistry and physics. The procedure and the reporting of this project are considered as more or less a "pioneering effort" in this field in South Dakota schools. Realizing that further study is needed and that unforeseen problems will arise, it is our intention to teach the same course in very much the same manner this coming school year of 1951-52 in the Watertown High School.

To others concerned in Education in South Dakota and those interested in the science field and in this study, we would make the following suggestions and recommendations:

1. Although this course has proven reasonably satisfactory in the Watertown High School, we do not claim that it will fit in, as is, into any other school. The administration and teaching of such a course in another high school and especially in the smaller high schools will have to be adapted to the circumstances. Since both writers have previously taught in small high schools, we believe that such a course is feasible and has possibilities in other high schools.
2. We recommend to those who would use the suggested outline to do so with the understanding that it was not intended as a course of study. Continued study and development are necessary to better determine a satisfactory content, proper sequence of topics, and an adjustment on time allotments.
3. It is also recommended that the teacher who undertakes to teach this course, have a good background in both physics and chemistry with college training in both.
4. We recommend that sufficient reference materials be supplied to both students and teacher. Since no single textbook suited to the course could be found, the availability of good reference material is imperative.

5. We recommend that this course be taught as a laboratory demonstration course and avoid making it a purely informational course. The demonstrations should be done largely by the pupils. Utilizing a number of interesting demonstrations will make a successful course more likely.
6. We recommend that an extensive testing program be employed throughout the course. Progress in, and mastery of each unit, should be checked by testing along with the regular instructional procedures. A wide variety of objective tests and problems should be constructed and used.
7. If we may be permitted, we offer a suggestion that the South Dakota State Department of Public Instruction plan and organize a workshop similar to the one which the State Department held on the campus of South Dakota State College during the summer of 1950. At that time a workshop was organized for setting up courses of study in Science for the Seventh and Eighth grades, for General Science in the Ninth grade, and for Biology in the Tenth grade. The purpose of the proposed workshop, a Physical Science Workshop, would be to produce an enriched course of study in Physics and Chemistry as well as a course of study for a Fused Course in Physics and Chemistry.

BIBLIOGRAPHY

- "The Acceptability of Physical Science as a College Entrance Unit", Science Education, XXX, (April 1946), Pp. 127-132.
- Beauchamp, Wilbur, "The Aims and Objectives of Science Teaching", Instruction in Science, Bulletin of the U.S. Bureau of Education, No. 17, and Monograph, No. 22, U.S. Department of Interior, Office of Education, Washington, D.C., 1932.
- Blanchet, W.W., "Subject-Matter Topics Contained in Textbooks For Use in Survey Courses in the Natural Sciences", Science Education, XXXII, (February 1948), Pp. 88-93.
- Cunningham, Harry A., "Laboratory Demonstration Versus Individual Laboratory Method in Science Teaching-A Summary", Science Education, XXX, (March 1946), Pp. 78-79.
- Curtis, F.D., Third Digest of Investigations in the Teaching of Science, Philadelphia, The Blakiston Co., 1939.
- Douglass, A.A., Modern Secondary Education, Boston, Houghton Mifflin Co., 1938, Pp. 630-636.
- Gwynn, J. Minor, Curriculum Principles And Social Trends, New York, The Macmillan Co., 1950, Pp. 215-216.
- Heidel, R.H., "A Comparison of the Outcomes of Instruction of the Conventional High School Physics Course and the Generalized High School Senior Science Course", Science Education, XXXVIII, (March 1944), Pp. 88-89.
- Hoff, Arthur G., Science Teaching, Philadelphia, The Blakiston Co., 1947.
- Hunter, George W., "Six Hundred Teachers Look at Science Trends", Science Education, XXXVIII, (February 1944), Pp. 14-25.
- Hurd, A.W., "The Textbook Versus Worksheets in Instruction", Education Administration and Supervision, XVII, 1931, Pp. 661-664.
- Lefler, R.W., "A Science Program for the Present Crisis", The Clearing House, XXV, (February 1951), P. 347.
- Miles, Vaden W., "A Determination of Principles and Experiments For An Integrated Course of Physical Science for High Schools", Science Education, XXXIII, (March 1949), Pp. 147-152.

Nelson, O.A., and Others, "Physical Science Today-A Symposium", The Science Teacher, XVIII, (February through December 1951), Pp. 13-21.

Noll, Victor H., The Teaching of Science in Elementary and Secondary Schools, New York, Longmans, Green and Company, 1939.

Peterson, Shailer, "The Evaluation of A One-Year Course, The Fusion of Physics and Chemistry, With Other Physical Science Courses", Science Education, XXXIX, (December 1945), Pp. 255-265.

Rush, R.I., "Determining and Implementing Objectives for a General Course in the Physical Sciences", Journal of General Education, XII, (January 1948), Pp. 138-143.

"Science Education In American Schools", Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, Chicago, Distributed by University of Chicago Press, 1947.

Wise, H.E., "A Synthesis of the Results of Twelve Curricular Studies in the Fields of Science Education", Science Education, XXXVII, (September-October 1943), Pp. 67-76.

Wiseman, C.R., "College-Entrance Credits of Graduates of South Dakota High Schools", The School Review, LV, (January 1947), Pp. 38-44.

APPENDIX A

Handbooks and Reference Books

A. Handbooks.

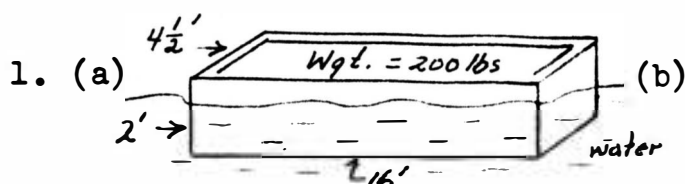
1. Basic Units in Physics, Frank E. Stewart, Republic Book Co., Inc., 115 E. 53rd St., New York 22, N.Y.
2. Basic Units in Chemistry, Joseph E. Johnston, Republic Book Co., Inc., 115 E. 53rd St., New York 22, N.Y.

B. Reference books.

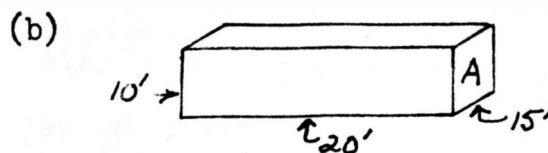
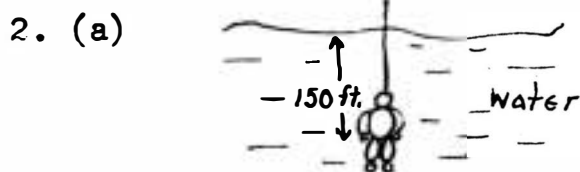
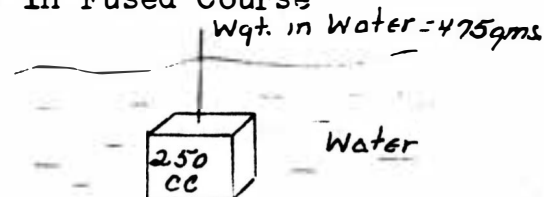
1. Elements of Chemistry, Brownlee, Fuller, Hancock, Sohon, and Whitsit, Allyn and Bacon, 1947.
2. Chemistry At Work, McPherson, Henderson, and Fowler, Ginn and Company, 1948.
3. Chemistry And Human Affairs, Price and Bruce, World Book Company, 1949.
4. Chemistry For Our Times, Weaver and Foster, McGraw-Hill Book Company, 1947.
5. Basic Chemistry, Bayles and Mills, The Macmillan Company, 1947.
6. Modern Chemistry, C.E. Dull, Henry Holt and Company, 1947.
7. Modern Physics, C.E. Dull, Henry Holt and Company, 1947.
8. Physics, A Basic Science, Burns, Verwiebe, and Hazel, D. Van Nostrand and Company, Inc., 1943.
9. Experiences in Physics, L.R. Willard, Ginn and Company, 1939.
10. Physics for Secondary Schools, Stewart and Cushing, Ginn and Company, 1932.
11. Physics of Today, Clark, Gorton, and Sears, Houghton Mifflin Company, 1940.
12. Elementary Practical Physics, Black and Davis, The Macmillan Company, 1938.

APPENDIX B

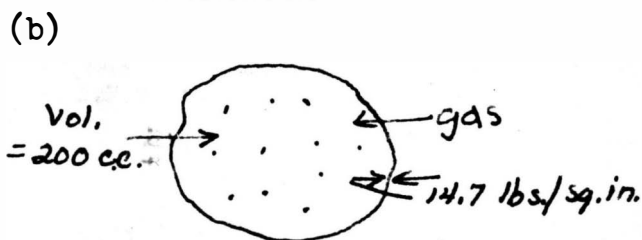
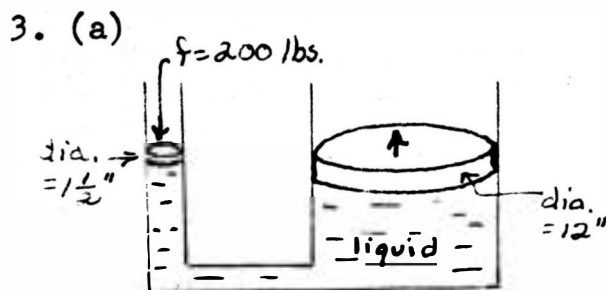
Illustration of Type of Worksheet Used in Fused Course



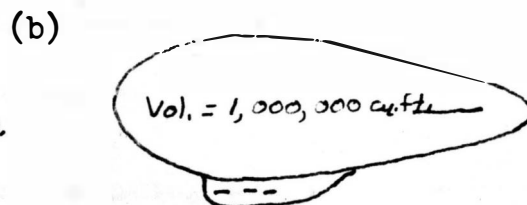
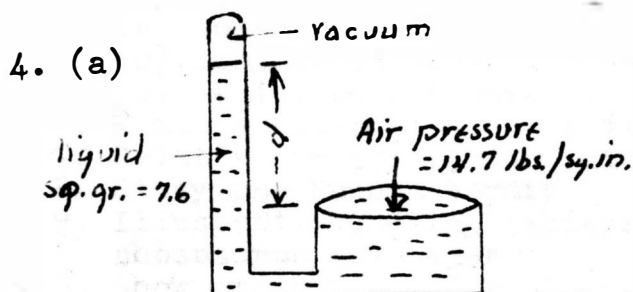
- (a) What weight may be added before it will sink in water? _____ lbs. (dimensions are in feet. Density of water 62.4 lbs./cu.ft.)
- (b) What does the object weight in air? _____ gms.



- (a) What pressure must be pumped into the diving suit? _____ lbs./sq.in.
- (b) What is the force against the end A if the container is full of water? _____ lbs.



- (a) Find the lift on the large piston. _____ lbs.
- (b) What will be its volume if the pressure is changed to 29.4 lbs./sq.in.? _____ cc.



- (a) Find the height d in inches. _____ in.
- (b) Weight of dirigible and gas is 50,000 lbs. Air weighs 1.3 oz./cu.ft. How much can it lift? _____ lbs.

APPENDIX C

Suggested List of Teacher and Pupil Demonstrations for the
Fused Course

Unit I.

1. Prepare a list of objects to be measured, determining dimensions and volume.
2. Weigh the objects in number one.
3. Make drawings of the atom as we visualize it.
4. Demonstrate osmosis using egg membrane, or animal membrane.
5. Demonstrate capillary action using two glass plates, or glass tubes of small diameter.
6. Demonstrate surface tension using glass of water and shingle nails, razor blade, or needle.
7. Show collection of gases by displacement of water.
8. Hooke's Law.
9. Demonstrate special properties of matter.
 - (a) Tenacity-try to pull a steel wire apart.
 - (b) Ductility-pull and stretch a thin copper wire.
 - (c) Malleability-hammer a piece of lead.
 - (d) Brittleness-break a piece of glass.
 - (e) Hardness-scratch a piece of glass with a cutter.
10. Determination of density.
11. Determination of specific gravity.
12. Weight change on heating a metal.
13. Heating of some common metals in air.
14. Purification by distillation.
15. Formation of oxides.

Unit II.

1. Prepare oxygen, showing properties.
2. Demonstrate the acid-type fire extinguisher.
3. Demonstrate unequal expansion, using ball and ring, and compound bar.
4. Demonstrate coefficient of linear expansion.
5. Demonstrate:
 - (a) Convection-using box and candle.
 - (b) Conduction-several dissimilar metals.
 - (c) Radiation-radiometer.
6. Mixture experiment, heat exchange.
7. Relative humidity, dew point.
8. Study the Bunsen burner.
9. Illustrate kindling temperature using white phosphorus and paper.
10. Show properties of explosive mixtures.
11. Examine a thermometer and test the boiling points of water and alcohol.
12. Test for carbon dioxide.

Unit III.

1. Archimedes' principle.
2. Atmospheric pressure-heat gallon can with few drops of water.

3. Lift pump, force pump, and the siphon.
4. Vector forces and force diagram-use three or more spring balances and string.
5. Determine the coefficient of friction.
6. Demonstrate principle of moments-use meter stick on fulcrum with two or more weights.
7. Demonstrate pulley, wheel and axle, inclined plane, lever.
8. Illustrate and show Venturi principle.
 - (a) Blow between two suspended balloons.
 - (b) Blow over a piece of paper.
 - (c) Blow through spool with card and needle at other end.
 - (d) Suspend ping-pong ball with air jet.
9. Balance glass of water on edge using a 25cent coin. (set half-full glass in groove).

Unit IV.

1. Demonstrate direct combination by using air and magnesium ribbon.
2. Show decomposition by heating mercuric oxide.
3. Let metallic sodium replace part of the hydrogen in water. Also allow zinc to react with hydrochloric acid.
4. Show by demonstration, reactions which go to an end through:
 - (a) Volatility.
 - (b) Insolubility.
 - (c) Non-ionization.
5. Demonstrate neutralization using phenolphthalein as an indicator.
6. Show that all salts are not neutral.
7. Compare the action of common metals on common acids.
8. Demonstrate different methods of preparing the same salt.
9. Study solubility of hydrogen chloride and ammonia in water.
10. Examine the solubility of potassium nitrate in cold and hot water.
11. Show conductivity of electrolytes.
12. Illustrate softening of hard water.
13. Demonstrate flame tests.
14. Verify a chemical calculation.

Unit V.

1. Demonstrate a resonating air column.
2. Demonstrate forced vibration, sympathetic vibration.
3. Suspend string on vibrator of electric bell and vary tension on string.
4. Demonstrate candlepower, inverse square law using five candles.
5. Locate image in plane mirror.

6. Demonstrate reflection of concave, convex mirrors.
7. Demonstrate refraction of lenses.
8. Show the spectrum using a prism.
9. Using red cellophane or red glass, notice color of blue and green objects.
10. Demonstrate polarized light.

Unit VI.

1. Plot magnetic field using permanent magnets and small compasses.
2. Demonstrate magnetic lines-using permanent magnets and iron filings.
3. Demonstrate static electricity:
 - (a) Rubber comb, scraps of paper.
 - (b) Rub balloon on wool clothing and it will cling to a wall.
 - (c) Charge an electroscope, discharge by grounding. Also discharge by holding burning match close.
4. Primary cell.
5. Wire three or four light bulbs in series and parallel.
6. Hook dry cells in series and parallel.
7. Take readings off old watt hour meter, or draw or make dials.
8. Demonstrate electrolysis.
9. Demonstrate a secondary cell.
10. Make an electromagnet.
11. Study circuit of electric bell and draw.
12. Draw and study diagram of electrical instruments.
13. Make a motor.
14. Show transformer principles.
15. Build a telegraph.
16. Build a simple radio-receiving set.

APPENDIX D

Example of Unit Test Used in Fused Course

Unit I. Examination--Fused Physics and Chemistry.

In the following true-false statements, place a plus sign for true and a circle for false.

- ___ 1. Science is of very little use in everyday living.
- ___ 2. The greatest contribution of science to humanity was the atomic theory.
- ___ 3. Ignorance and superstition have often blocked the path of progress.
- ___ 4. The scientific attitude implies that we know there is a cause for every happening.
- ___ 5. In the scientific method, facts are the deciding factors.
- ___ 6. "What we don't know won't hurt us".
- ___ 7. A "scientific guess" is known as a conclusion.
- ___ 8. There would be more grams in a decigram than in a decagram.
- ___ 9. A liter of water weighs one kilogram.
- ___ 10. The centimeter and milliliter are about the same thing.
- ___ 11. In a chemical reaction, the volume of the reactants will always equal the volume of the products.
- ___ 12. It would not be logical to state the density of a substance in ounces per cc.
- ___ 13. The weight of an object may change, but its mass does not.
- ___ 14. An atom always gains or loses electrons in a chemical reaction.
- ___ 15. If a equals b divided by c , then b divided by a equals c .
- ___ 16. The density of a substance is 3.2 gm/cc. A liter of it will weigh 3200 gms.
- ___ 17. An element cannot be separated into any simpler substance by ordinary chemical means.
- ___ 18. The volume of a substance will vary as conditions of temperature and pressure vary.
- ___ 19. The density of any given substance will not change.
- ___ 20. The mass of a substance is best measured by a scale.

In the following, write the name in the given blank which you think best fits the description which follows.

- ___ 1. An atom which has gained or lost electrons.
- ___ 2. Fundamental unit of all matter.
- ___ 3. Ability to do work.
- ___ 4. Tendency of a body at rest to remain at rest.
- ___ 5. Matter which has neither a definite shape or definite volume.
- ___ 6. An atom which contains an abnormal number of neutrons.
- ___ 7. Type of charge an atom takes when it loses electrons.

- _____ 8. Name given to type of compound formed by sharing electrons.
- _____ 9. A name given any substance which cannot be divided into any simpler substance by ordinary means.
- _____ 10. A substance of varying composition.
- _____ 11. Kind of energy illustrative of coal.
- _____ 12. Form of energy in the storage battery.
- _____ 13. Name given to elements which lose electrons in a reaction.
- _____ 14. A substance whose composition never varies.
- _____ 15. A unit of volume in English system about same as the liter.
- _____ 16. Attraction between like molecules.
- _____ 17. Mass of an object divided by its volume.
- _____ 18. Name given to electrons in outer orbit of atom.
- _____ 19. Stands for one atom of an element.
- _____ 20. Unit in metric system resembling somewhat our mile.

In the following, there are three choices. Place the letter a for the first choice, the letter b for the second, and c for the third.

- _____ 1. When the temperature of a substance rises, its density usually (a. becomes less; b. becomes greater; c. remains the same).
- _____ 2. The state of matter in which the molecules are moving the most rapidly is in a (a. solid; b. liquid; c. gas).
- _____ 3. An atom has an atomic number of 13. The element is therefore a(an) (a. metal; b. non-metal; c. amphoteric element).
- _____ 4. An atom which does not give or take electrons will form (a. covalent; b. coordinate; c. ionic) compounds.
- _____ 5. When a liquid changes to a gas, the molecules (a. speed up; b. slow down; c. remain the same).
- _____ 6. A liquid is pulled up in a small tube by (a. adhesion; b. cohesion; c. both).
- _____ 7. Dissolving table salt in water is an example of (a. a physical change; b. chemical change; c. energy change).
- _____ 8. When a substance undergoes a chemical change it will (a. gain in weight; b. gain in volume; c. appear differently).
- _____ 9. As a liquid becomes warmer, the molecules (a. increase their size; b. decrease their velocity; c. increase their kinetic energy).
- _____ 10. The property of a metal which shows its ability to be pounded into thin sheets is termed (a. ductility; b. malleability; c. luster).
- _____ 11. The (a. volume; b. weight; c. mass) of a substance never changes.
- _____ 12. The basic unit of the metric system is a unit of (a. volume; b. mass; c. linear measure).
- _____ 13. The density of a substance is 3.2 gm/cc. Expressed in the English system, it would be (a. 3.2 lbs/cu.ft.; b. 3.2 lbs/cu.in.; c. 199.68 lbs/cu.ft.).

- ___14. When a chemical reaction occurs, energy is (a. not always required; b. usually released; c. always required).
- ___15. An atom takes a (a. positive; b. negative; c. neutral) charge when it gains electrons to complete its outer ring.
- ___16. $(\text{NH}_4)_2\text{SO}_4$ has (a. 11; b. 13; c. 15) atoms in molecule.
- ___17. The hydrogen atom combines with another hydrogen atom by (a. covalent; b. electrovalent; c. coordinate) bonding.
- ___18. The ratio of hydrogen to oxygen by weight in water is (a. 8 to 1; b. 1 to 8; c. 1 to 9).
- ___19. The pressure exerted upward above a liquid is called (a. atmospheric pressure; b. surface tension; c. vapor pressure).
- ___20. The boiling point of a liquid will (a. rise; b. lower; c. remain same) when the barometer falls.

In the following, write the letter from the right-hand column in the space at the left.

- | | |
|--|---------------------------|
| ___1. A compound formed by sharing electrons | A. neutron. |
| ___2. Law of definite proportions. | B. electron. |
| ___3. Molecular weight of a substance. | C. symbol. |
| ___4. Quantity of matter. | D. electrovalent. |
| ___5. Positively charged particle. | E. mass. |
| ___6. Represents one atom of an element. | F. density. |
| ___7. Element used in comparing weights of other atoms. | G. covalent. |
| ___8. Law of multiple proportions. | H. sum of atomic weights. |
| ___9. Proposed the atomic theory. | I. molecule. |
| ___10. Part of an atom which revolves about the nucleus. | J. Proust. |
| ___11. Smallest particle of a substance which still has all properties of substance. | K. oxygen. |
| ___12. Discovered oxygen. | L. proton. |
| ___13. Energy due to motion. | M. Dalton. |
| ___14. Compounds formed by exchanging electrons. | N. Priestley. |
| ___15. Measure of pull of gravity upon an object. | O. kinetic. |
| | P. potential. |
| | Q. weight. |

In the following questions, write the word or phrase necessary to complete the meaning of the statement.

1. An atom possesses () balance, while the ion possesses () balance.
2. The density of a substance is found by dividing its () by its ().
3. Atomic study shows that when an atom loses electrons in a reaction, it should be termed a ().
4. The smallest or simplest of all atoms is the () atom.
5. The most abundant of all the elements is ().
6. In general, metals combine with ().
7. Compounds can be separated into two or more ().

8. The volume of a substance is found by dividing its () by its ().
9. The density of a substance is expressed in () in the metric system.
10. A scientific guess is known as a ().
11. A scientific () is discovered, not made.
12. Atoms of any kind may not contain more than () orbits.
13. Two atoms which have the same atomic number, but different atomic weights are termed ().
14. Of necessity, any substance is composed of either molecules or ().
15. The word () means indivisible.

Thought problems.

1. John noticed that Edward was boiling water; so he put a thermometer into the water and found that the water was boiling at 185 degrees Fahrenheit. What would your conclusions be as to what John and Edward were doing?
2. If air weighs 1.29 gm. per liter, how much do you think the air would weigh in this room if the room is 20 ft. long, 16 ft. wide, and 15 ft. high? A cubic foot contains $7\frac{1}{2}$ gal. Do you think you could lift the air in this room?
3. If gravity pulls upon an object in direct proportion to its mass, should a heavier person be pulled faster than a lighter one? State your reason.
4. Do you think an object would fall towards the earth in a complete vacuum?
5. Do you think that all accidents are avoidable? State your reason or reasons. Give an example if it helps.

APPENDIX E

Final Examination Prepared by Writers for Fused Course

In the following true-false statements, use a plus sign for true, and a circle for false.

- _____ 1. A wire which is 23.4 cm. in length would also be 234 mm. in length.
- _____ 2. In a chemical change, we may easily recognize the products as they will have the properties of the original reactants.
- _____ 3. A chemical mixture always contains the same elements in the same proportion by weight.
- _____ 4. An ion of an element contains the same number of protons as the atom of the same element.
- _____ 5. A few common metals will not react with sulfuric acid.
- _____ 6. An atom having three electrons in its outer ring would probably be classed as a metal.
- _____ 7. When an atom gains electrons, it takes a positive charge.
- _____ 8. Solutions are examples of chemical compounds.
- _____ 9. Carbon forms most of its compounds by electrovalent bonding.
- _____ 10. If an atom has lost two electrons, the ion has a valence of a minus two.
- _____ 11. Carbon is used to take oxygen away from many metals.
- _____ 12. A covalent compound is usually a good electrolyte.
- _____ 13. All water-soluble acids are electrolytes.
- _____ 14. The molecular weight of water is sixteen.
- _____ 15. Water is a chemical compound.
- _____ 16. Water is a poor conductor of electricity.
- _____ 17. The atomic weight of an atom is always greater than its atomic number.
- _____ 18. Most chemical reactions are easily reversible.
- _____ 19. Oxygen can replace chlorine in a chemical reaction.
- _____ 20. In N_2O_5 , the valence of nitrogen is 4.
- _____ 21. Compounds with high positive heats of formation are quite stable.
- _____ 22. An alloy is a mixture of two or more metals.
- _____ 23. The density of air is less than the density of carbon dioxide.
- _____ 24. Carbon tetrachloride is used in fire extinguishers.
- _____ 25. Water will react with sulfur trioxide to form sulfuric acid.

In the following multiple-choice questions, place the letter in the blank at the left which best completes the meaning of the statement.

- _____ 1. Energy is (a) liberated; (b) absorbed; (c) changed; (d) destroyed, when a liquid changes to a gas.
- _____ 2. A molecule (a) contains two or more atoms; (b) contains two or more unlike atoms; (c) may contain one atom; (d) is variable in composition for a given compound.

- ____ 3. The atomic number of an element tells us (a) number of neutrons; (b) number of orbits; (c) number of protons; (d) number of electrons in the ion.
- ____ 4. Any chemical reaction which gives off visible light and heat is termed (a) combustion; (b) burning; (c) oxidation; (d) electrolysis.
- ____ 5. When a metal reacts with an acid, (a) the metal gains electrons; (b) the metal is unaffected; (c) the gas hydrogen is liberated; (d) hydrogen ion loses electrons.
- ____ 6. An atom (a) always; (b) usually; (c) may; (d) never has more than eight electrons in its outer ring.
- ____ 7. When iron unites with oxygen, it (a) gains electrons; (b) loses electrons; (c) shares electrons; (d) loses in valence.
- ____ 8. An acid will (a) be very soluble in water; (b) highly ionize; (c) contain hydrogen ions in water solution; (d) turn red litmus blue.
- ____ 9. If an electric current is passed through molten table salt, the (a) sodium ions lose electrons at the anode; (b) the chlorine ions lose electrons at the anode; (c) sodium metal is found at the anode; (d) the process is termed electroplating.
- ____ 10. The valence of sulfur in sulfuric acid is (a) plus 6; (b) plus 3; (c) plus 2; (d) minus 2.
- ____ 11. (a) Carbon; (b) nitrogen; (c) chlorine; (d) oxygen is a very inactive element forming relatively unstable compounds.
- ____ 12. When table salt reacts with sulfuric acid, one of the products is (a) hydrogen; (b) chlorine; (c) sodium; (d) hydrogen chloride.
- ____ 13. The reaction between a metal and an acid always produces (a) hydrogen; (b) an acid; (c) water; (d) a salt.
- ____ 14. The smallest particle of a substance which has the properties of that substance is (a) an ion; (b) an atom; (c) a molecule; (d) an element.
- ____ 15. Acids whose names end in -ic have radicals whose names end in (a) -ite; (b) -ate; (c) -oic; (d) -ol.
- ____ 16. When sodium combines with chlorine, (a) heat is liberated; (b) heat is absorbed; (c) an acid is formed; (d) a base is formed.
- ____ 17. All atoms of the same element contain the same number of (a) protons; (b) neutrons; (c) positrons; (d) negatrons.
- ____ 18. The ratio of hydrogen to oxygen in water by weight is (a) 1 to 16; (b) 8 to 1; (c) 1 to 8; (d) 2 to 1.
- ____ 19. Molecules of most gases contain (a) 1; (b) 2; (c) 3; (d) 4 atoms.
- ____ 20. The most abundant gas in the atmosphere is (a) oxygen; (b) carbon dioxide; (c) water vapor; (d) nitrogen.

Place the letter from the right-hand column which is best associated with the term at the left.

- | | |
|-------------------------------|-----------------------------------|
| _____ 1. density. | A. most used solvent. |
| _____ 2. specific gravity. | B. molecules. |
| _____ 3. formulas. | C. heavy hydrogen. |
| _____ 4. mercuric oxide. | D. covalent. |
| _____ 5. speed up. | E. weight divided by volume. |
| _____ 6. water. | F. deoxidizing. |
| _____ 7. isotope. | G. catalyst. |
| _____ 8. allotropic. | H. weight compared to a standard. |
| _____ 9. reduction. | I. ozone. |
| _____ 10. hydrogen. | J. cathode. |
| _____ 11. carbon. | K. electrolyte. |
| _____ 12. positive electrode. | L. Priestley. |
| _____ 13. ionic. | M. Cavendish. |
| _____ 14. separation. | N. anhydride. |
| _____ 15. oxidation. | O. deliquescent. |
| | P. distillation. |
| | Q. anode. |
| | R. loss of electrons. |

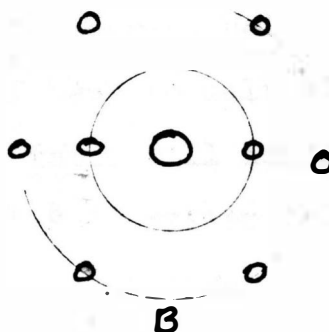
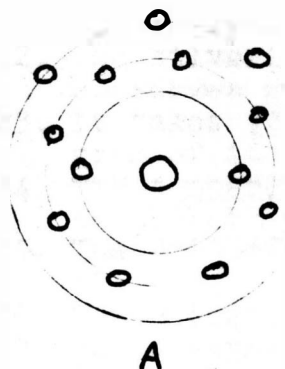
In the following completion questions, print the word in the blank at the left which best completes the meaning of the statement.

- _____ 1. Anything which occupies space and has weight is defined as (1).
- _____ 2. Any substance which cannot be divided into any simpler substances by ordinary chemical means is a (an) (2).
- _____ 3. Oxygen unites with most elements to form (3).
- _____ 4. An atom having an atomic number of 16 would have (4) orbits.
- _____ 5. An atom which has a complete outer ring or orbit is termed (5).
- _____ 6. The (6) of an ion is determined by the number of electrons lost or gained in a reaction.
- _____ 7. A (an) (7) is the term applied to a substance being dissolved in a solvent to form a solution.
- _____ 8. An atom always has the same number of electrons as it has (8).
- _____ 9. The most active non-metal is (9).
- _____ 10. An atom which has gained or lost electrons is termed a (an) (10).
- _____ 11. Dissolved solids (11) the freezing point of a solvent.
- _____ 12. The reaction between an acid and a base is called (12).
- _____ 13. A (an) (13) substance absorbs moisture from the air.
- _____ 14. In general, the warmer a solvent the (14) of a substance it can dissolve.
- _____ 15. An ion composed of two or more atoms is termed a (an) (15).
- _____ 16. As the temperature of a gas increases, its (16) increases provided its volume remains constant.

- _____ 17. Fifty degrees Fahrenheit will be (17) degrees Centigrade.
- _____ 18. All organic compounds contain the element (18).
- _____ 19. If (19) is passed through limewater, a white precipitate occurs.
- _____ 20. The most abundant element on the earth's surface is (20).
- _____ 21. All (21) contains the hydroxide ion in water solution.
- _____ 22. A (22) is a combination of positive and negative ions.
- _____ 23. If any solution conducts an electric current small particles called (23) must be present in solution.
- _____ 24. If the (24) remains constant, the volume of a gas varies inversely with the pressure.
- _____ 25. A (25) contains the same elements in the same proportion by weight.

Problems:

1. What weight of zinc will react with 100 gms. of available sulfuric acid in dilute solution?
2. Write the equation for the burning of hydrogen.
3. How many atoms are there in a molecule of ammonium sulfate?
4. What percent of pure ferric oxide is iron?
5. (a) What is the valence of the ion of A? _____
 (b) What is the valence of the ion of B? _____
 (c) Write the formula for AB. _____



Write plainly in the blank at the left, the word or words omitted. In some cases, the answer will consist of a formula or numbers.

- _____ 1. The tendency of a body in motion to remain in motion is (1).
- _____ 2. The ability of a material to be hammered into thin sheets is (2).
- _____ 3. A razor blade can be made to float because of (3).
- _____ 4. .9 meter equals (4) centimeters.
- _____ 5. 3 kilograms equal (5) pounds.
- _____ 6. The density of water is (6) lbs. per (7).
- _____ 7.
- _____ 8. (8) law states that a pressure applied to an enclosed fluid will be transmitted undiminished in all directions.
- _____ 9. A hollow glass tube designed to measure the specific gravity of a liquid is called a (9).
- _____ 10. The law of buoyancy was first announced by (10).
- _____ 11. The weight of air exerts a pressure of (11) per square inch.
- _____ 12. A force which can do the same thing as two or more other forces is called (12).
- _____ 13. When velocity is continually changing it is called (13) velocity.
- _____ 14. When a body is most difficult to tip over, it is said to be in (14) equilibrium.
- _____ 15. A rotating body experiences an outward force called (15) force.
- _____ 16. Force times the distance through which it moves is defined as (16).
- _____ 17. The efficiency of machines is expressed as a ratio of (17).
- _____ 18. The mechanical advantage of any machine is the ratio of (18).
- _____ 19. The degree Fahrenheit is (larger, smaller) than the degree Centigrade.
- _____ 20. The lowest possible temperature on the Centigrade scale is (20).
- _____ 21. The process whereby heat travels along a metal rod is referred to as (21).
- _____ 22. The silvering process in a thermos bottle conserves heat by reducing transfer by (22).
- _____ 23. It takes (23) calories of heat to melt one gram of ice.
- _____ 24. The temperature at which water will condense on objects is known as (24).
- _____ 25. The unit of heat in the F.P.S. system is the (25).
- _____ 26. Sound (can, cannot) travel in a vacuum.
- _____ 27. Sound waves are (transverse, longitudinal).
- _____ 28. The reflection of confused sound waves is called (28).

- _____ 29. When you sing a single pitch next to an open piano, the strings will respond with the same pitch. This occurrence is termed (29).
- _____ 30. The sound of the note C of a violin can be distinguished from that of a trombone because of (30).
- _____ 31. The heavier the string, the (31) the pitch.
- _____ 32. The tighter the wire, the (32) the pitch.
- _____ 33. Radio waves are (faster, the same, slower) than light waves.
- _____ 34. A material through which an object can be clearly seen is said to be (34).
- _____ 35. As a light ray passes from water to air, it seems to be bent. This phenomenon is called (35).
- _____ 36. When light waves are scattered by being reflected from a rough surface, it is called (36).
- _____ 37. When the reflected rays of a mirror only seem to meet, the image is classified as (37).
- _____ 38. A person who is farsighted should wear (38) lenses.
- _____ 39. In red light, the color of a blue tie is (39).
- _____ 40. An incandescent solid will give a (40) spectrum.
- _____ 41. Magnetic lines of force are said to go from (41).
- _____ 42. A substance, like iron, which is easily magnetized is said to be (42).
- _____ 43. An electrical instrument that determines the presence of a charge is called a (an) (43).
- _____ 44. An apparatus that actually stores electricity is called a (44).
- _____ 45. Often in the simple cell, impurities are found in one of the elements which decreases the efficiency of the cell. This is termed (45).
- _____ 46. The defect in question 45 can be eliminated by (46).
- _____ 47. Overloading a wire is more easily done in (series, parallel) wiring.
- _____ 48. When the external resistance is small, it is better to hook the dry cells in (series, parallel).
- _____ 49. The strength of an electromagnet depends on
- _____ 50. (49) and (50).
- _____ 51. In a telegraph circuit, when the incoming signal is weak, it may be amplified by means of a (51).
- _____ 52. The object to be plated in an electroplating process is usually attached to the (52) terminal.
- _____ 53. Faraday showed that the amount of metal deposited
- _____ 54. depended on (53), (54), and (55).
- _____ 55.
- _____ 56. An instrument which shows the direction of small amounts of current is a (an) (56).
- _____ 57. In a step-up transformer, the current in the primary coil (57) a current in the secondary coil.
- _____ 58. A generator that uses slip rings produces (58) current.
- _____ 59. A device which lets current go through one way only, is called a (59).
- _____ 60. When a radio tube operates the current flows only from (60) to the plate.

In the following problems, put the answer in the blank at the left. Be sure that your answer is labeled correctly.

- _____ 1. A tank is 4 feet wide and 6 feet long. What is the total weight of water in the tank when the water is 5 feet deep?
- _____ 2. What is the pressure per square inch at the bottom of the tank in problem number one?
- _____ 3. A boy weighs 125 lbs. What is his weight in kgs.
- _____ 4. A timber is 6 in. by 6 in. by 8 ft. If the sp. gr. of wood is .8, what is the weight of the timber?
- _____ 5. A given gas is under 40 lbs/sq.in. pressure and occupies 120 cu. in. When the gas is compressed to 90 cu. in., what is its new pressure?
- _____ 6. An elephant weighs 3200 lbs. By means of its trunk it lifts an actress weighing 120 lbs. a distance of $6\frac{1}{2}$ ft. off the ground. How much work did the elephant do?
- _____ 7. A boy weighing 75 lbs. balances another boy weighing 100 lbs. on a see-saw. If the smaller boy is 4 ft. from the fulcrum, how far away is the larger from the fulcrum?
- _____ 8. An object falls for 3 seconds. How far does the object fall?
- _____ 9. How fast is the object falling at the end of 3 seconds in problem 8?
- _____ 10. Change 30 degrees C. to F.
- _____ 11. 150 grams of copper are cooled from 90 deg. C. to 45 deg. C. The sp. heat of copper is .095. How many calories are given up?
- _____ 12. The echo of a shot was heard 5 seconds after it was fired. The air temperature was 20 deg. C. How far away was the reflecting surface?
- _____ 13. The fundamental of a note is 120 vib/sec. What is the frequency of the third overtone?
- _____ 14. An object is 4 feet tall when it is 10 feet from the lens of a camera. If the image is 4 in. tall in the camera, how far is the film from the lens?
- _____ 15. The object distance is 12 inches and the image distance is 60 inches. What is the focal length of the lens?
- _____ 16. What must be the candle power of a lamp that will give an intensity of illumination of 2 foot candles at a distance of 10 feet?
- _____ 17. Three resistances are hooked in series. Their respective resistances are 4, 6, and 10 ohms. When the voltage is 35 volts, what current will flow?
- _____ 18. Two resistances 4 and 6 ohms are hooked in parallel to two dry cells in series. What current will flow?
- _____ 19. Calculate the calories developed in a percolator using 4.5 amps at 110 volts for 20 minutes.
- _____ 20. The primary of a transformer carries 110 volts and 5 amps. The secondary is delivering 10 volts and how many amps?

NEW CALIFORNIA SHORT-FORM TEST OF MENTAL MATURITY ADVANCED '47 S-FORM

Devised by Elizabeth T. Sullivan, Willis W. Clark, and Ernest W. Tiegs

Occupation
or Grade

Age Birthday Sex: M-F

Business or
Institution

TEST FACTORS	Possible Score	Examinee's Score	Mo. Yr.	DIAGNOSTIC PROFILE (Chart scores here)																Percentile Rank		
				Mental Age																		
				120	132	144	156	168	180	192	204	216	228	240	300	360						
				10	11	12	13	14	15	16	17	18	19	20	25	30						
Verbal Relationships	35			10		15		20		25		30		35								
1. Sensing Right and Left*	20			10	11	12	13	14	15	16	17	18	19	20								
2. Manipulation of Areas*	15			2	3		4		5	6	7	8	9	10	11	12	13	14	15			
3. Logical Reasoning	30			10		15		20		25		30										
4. Similarities*	15			4	7		8		9		10		11	12	13	14						
5. Inference	15			2	3	4	5	6	7	8	9	10	11	12	13	14	15					
6. Numerical Reasoning	30			5				10		15		20		25		30						
7. Number Series*	15			2		3		4		5		6	7	8	9	10		15				
8. Numerical Quantity	15			3		4		5		6		7	8	9	10	11	12	13	14	15		
9. Vocabulary (Test 7)	50			1	2	5	6	7	8	9	10	11	12	13	14	15	20	25	30	40	45	48
10. Total Mental Factors	145			21	27	33	40	48	56	64	71	78	85	92	122	140						
11. Language Factors (4+6+7)	80			5	8	10	14	18	23	28	33	37	42	46	66	77						
12. Non-Language Factors (1+2+3+5)	65			16	19	22	26	30	33	36	38	41	43	46	56	63						
13. Chronological Age				120	132	144	156	168	180	192	204	216	228	240	300	360						
14. Actual Grade Placement				10	11	12	13	14	15	16	17	18	19	20	25	30						
Grade examinee is in.				5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	16.0								
				10	11	12	13	14	15	16	17	18	19	20	25	30						
				120	132	144	156	168	180	192	204	216	228	240	300	360						

SUMMARY OF DATA

Total Mental Factors

Language Factors

Non-Language Factors

Score

M. A.

+

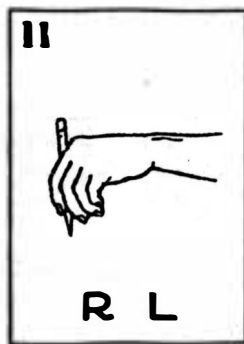
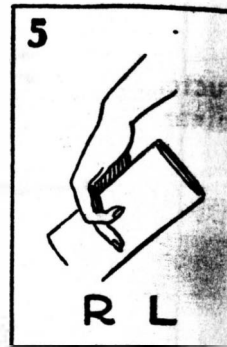
C. A.

=

I. Q.

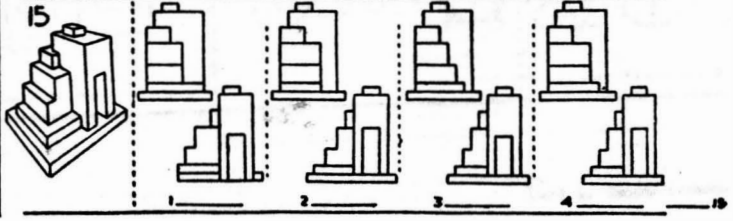
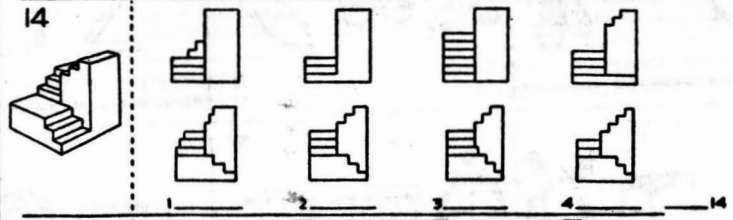
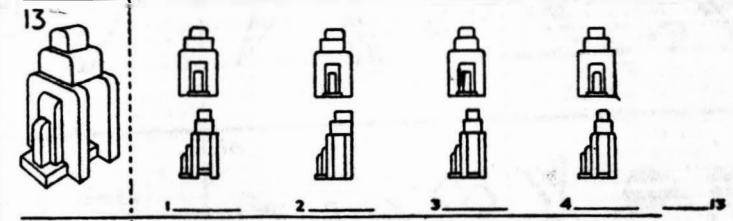
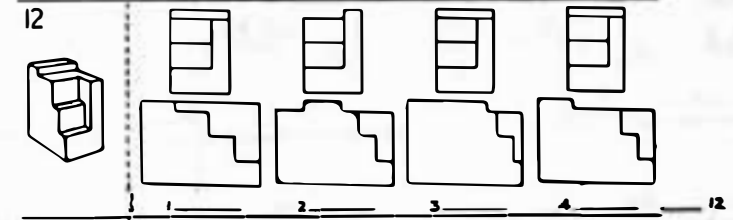
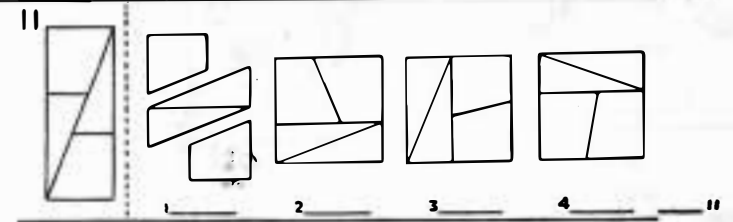
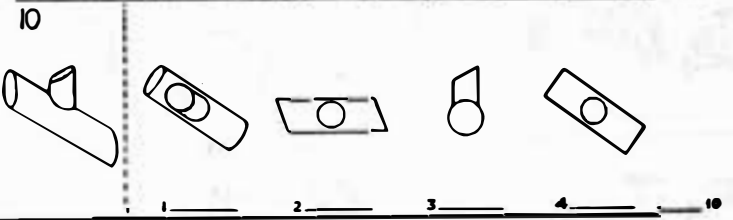
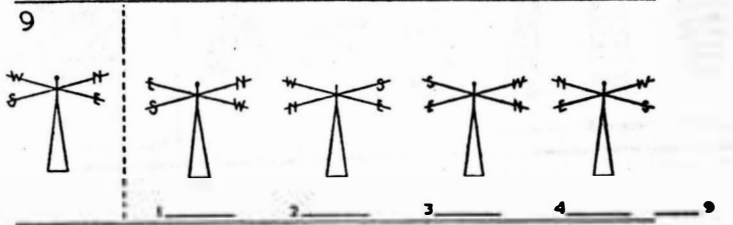
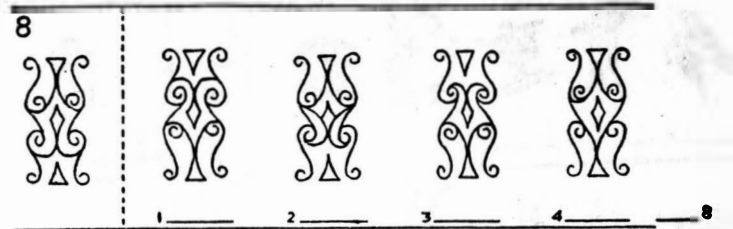
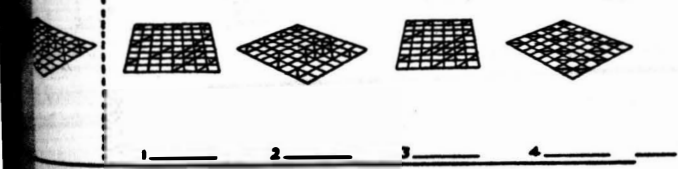
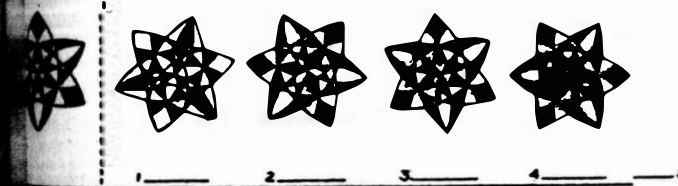
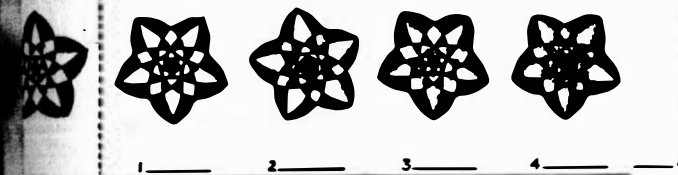
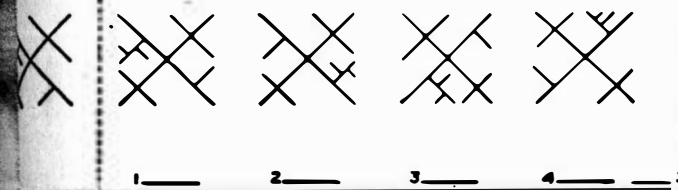
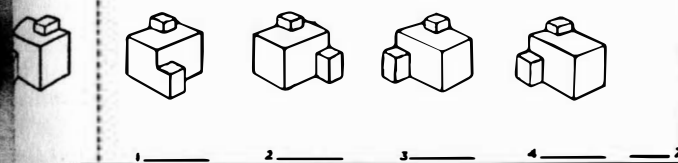
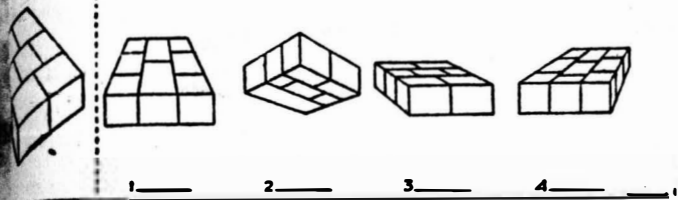
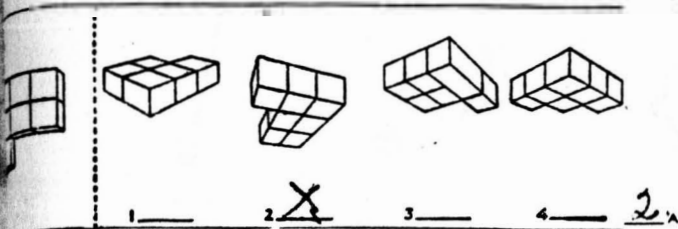
TEST 1.

Directions: Put a circle around the letter R in all rights. Put a circle around the letter L in all lefts.



TEST 2.

Directions: In each row find a drawing that is either the same drawing or different views of the first drawing. Put an X on the line under this drawing and put the number of the drawing you mark on the line to the right.



TEST 3.

Directions: The first three objects in each row are alike in some way. Find another object in the same row that belongs with them. Put an X on the line under it and put the number of the object you mark on the line to the right.

<p>A</p>	<p>1. 2. 3. <u>X</u> 4. 3</p>	<p>8</p> <p>1. 2. 3. 4.</p>	<p>1. 2. 3. 4.</p>
<p>1</p> <p>1. 2. 3. 4. 1</p>	<p>1. 2. 3. 4.</p>	<p>9</p> <p>1. 2. 3. 4.</p>	<p>1. 2. 3. 4.</p>
<p>2</p> <p>1. 2. 3. 4. 2</p>	<p>1. 2. 3. 4.</p>	<p>10</p> <p>1. 2. 3. 4.</p>	<p>1. 2. 3. 4.</p>
<p>3</p> <p>1. 2. 3. 4. 3</p>	<p>1. 2. 3. 4. 3</p>	<p>11</p> <p>1. 2. 3. 4.</p>	<p>1. 2. 3. 4.</p>
<p>4</p> <p>1. 2. 3. 4. 4</p>	<p>1. 2. 3. 4. 4</p>	<p>12</p> <p>1. 2. 3. 4. 4</p>	<p>1. 2. 3. 4.</p>
<p>5</p> <p>1. 2. 3. 4. 5</p>	<p>1. 2. 3. 4. 5</p>	<p>13</p> <p>1. 2. 3. 4. 5</p>	<p>1. 2. 3. 4.</p>
<p>6</p> <p>O S C T E U Z</p> <p>1. 2. 3. 4. 6</p>	<p>1. 2. 3. 4. 6</p>	<p>14</p> <p>1. 2. 3. 4. 6</p>	<p>1. 2. 3. 4.</p>
<p>7</p> <p>1. 2. 3. 4. 7</p>	<p>1. 2. 3. 4. 7</p>	<p>15</p> <p>1. 2. 3. 4. 7</p>	<p>1. 2. 3. 4.</p>

TEST 4.

Directions: Read each group of statements and draw a line under the correct logical answer.
Write the number of this answer on the line to the right.

0. All four-footed creatures are animals.
All horses are four-footed. Therefore

- ¹ Creatures other than horses can walk
- ² All horses can walk
- ³ All horses are animals

3 0

1. Elm Street is parallel to Oak Street.
Oak Street is parallel to Palm Avenue.
Therefore

- ¹ Elm Street crosses Palm Avenue
- ² Palm Avenue is longer than Elm Street
- ³ Elm Street is parallel to Palm Avenue

1

2. George Washington was a skillful general.
George Washington was President of the United States. Therefore

- ¹ Skillful generals make good presidents
- ² A President of the United States was a skillful general
- ³ Good presidents make skillful generals

2

3. If he steers toward the land he will be wrecked; and if he steers toward the open sea he will be wrecked; but, he must steer either toward the land or toward the open sea.
Therefore

- ¹ He should head for the open sea
- ² The coast is dangerous for ships
- ³ He will be wrecked

3

4. If the wind changes it will either grow warmer or it will storm.
The wind does not change. Therefore

- ¹ It will probably grow warmer
- ² The conclusion is uncertain
- ³ It will not grow warmer nor will it storm

4

5. X is younger than Y.
Y is younger than Z. Therefore

- ¹ Y is younger than X
- ² X is younger than Z
- ³ Y has lived longer than Z

5

6. All circles are round figures.
The figure is not round. Therefore

- ¹ It is oval
- ² It is either a square or a triangle
- ³ It is not a circle

6

7. A is situated to the east of B.
B is situated to the east of C. Therefore

- ¹ C is situated close to A
- ² A is situated to the east of C
- ³ C is nearer to A than to B

7

8. If he is to complete his high school course, he must avoid wasting his energy and his money.

But he will not avoid wasting his energy, or he will not avoid wasting his money. Therefore

- ¹ He will not complete his high school course
- ² He will be sorry some day
- ³ He should be criticized for not doing better

8

9. If the students are in error, your refusal to listen to their side is unreasonable.
If they are not in error, your refusal is unjust.
But, the students are in error or they are not.
Therefore

- ¹ Your refusal is justifiable
- ² Your refusal is either unreasonable or it is unjust
- ³ Your refusal may be reconsidered later

9

10. Three boys are up on a ladder,
Tom is farther up the ladder than Paul.
Jim is farther up than Tom.

Which boy is in the middle position on the ladder?

- ¹ Tom
- ² Paul
- ³ Jim

10

11. A is either B or C or D.
A is not B. Therefore

- ¹ A is C
- ² A is either C or D
- ³ The conclusion is uncertain

11

12. If he were loyal he would not speak unkindly of his family in earnest.
If he were wise he would not speak unkindly of them in jest.
Either he speaks unkindly in earnest or in jest.
Therefore

- ¹ He is either not loyal or not wise
- ² He is unkind
- ³ The conclusion is uncertain

12

13. If A is B, E is F; if C is D, G is H.
Either A is B or C is D. Therefore

- ¹ A is F or C is H
- ² Either E is F or G is H
- ³ The conclusion is uncertain

13

14. A is between B and C.
B is between C and D. Therefore

- ¹ A is not between C and D
- ² A is between B and D
- ³ A is nearer to B than to D

14

15. Five cities (P, Q, R, S, and T) are in the same state. S is between P and Q. T is between P and S. R is the same distance from P and T and S is the same distance from P and Q.
Therefore

- ¹ Q is nearer to T than to S
- ² R is nearer to Q than to P
- ³ T is nearer to P than to Q

15

TEST 5.

Directions: In each row of numbers below, there is one that is wrong. Find this wrong number among the answer numbers on the right, and write its letter on the line to the right. In Sample A, the wrong number is 9, so letter *c* is written on the line to the right.

Sample:

A. 2 4 6 8 9 10

Answers

A. a 10 b 6 c 9 d 2 e 8 C A

(1). 18 15 13 12 9 6 3

a 13 b 12 c 6 d 3 e 9 _____ 1

(2). $\frac{1}{2}$ 0 1 2 4 8 16

a 1 b $\frac{1}{2}$ c 0 d 8 e 16 _____ 2

(3). 4 5 7 10 11 13 14 16 17 19

a 16 b 5 c 19 d 17 e 14 _____ 3

(4). 56 49 43 38 35 34 31 29

a 31 b 38 c 35 d 29 e 43 _____ 4

(5). 7 9 10 13 16 19

a 10 b 9 c 13 d 7 e 19 _____ 5

(6). 27 25 22 17 12 7

a 27 b 22 c 25 d 12 e 17 _____ 6

(7). 3 5 6 11 12 14 15 19 20 21

a 19 b 21 c 15 d 14 e 20 _____ 7

(8). 37 34 31 29 27 24 22 21 19

a 31 b 27 c 21 d 37 e 22 _____ 8

(9). 1 2 4 7 11 15 16 22

a 22 b 7 c 15 d 1 e 16 _____ 9

(10). 18 21 19 22 20 22 23 21 24

a 18 b 23 c 21 d 20 e 22 _____ 10

Go right on with the following until told to stop. In each row of numbers below, the numbers increase or decrease in accordance with a definite series of whole numbers. Decide what numbers are missing, find them among the answers at the right, and write the letter of your choice for the correct answer on the line to the right. In Sample B, the missing numbers are 4, 12, so letter *c* is written on the line to the right.

Sample:

B. 2 7 9 14 17

Answers

a 3, 11 b 4, 11 c 4, 12 d 5, 11 e 3, 12 C B

(11). 15 16 18 21 24 25

a 20, 23, 27 b 19, 22, 27 c 19, 23, 29
d 20, 22, 26 e 19, 23, 27 _____ 11

(12). 17 19 23 26 28 29

a 21, 22, 24 b 20, 21, 25 c 20, 21, 24
d 20, 22, 25 e 21, 22, 25 _____ 12

(13). 27 29 28 27 24 23

a 22, 24, 26 b 21, 25, 27 c 22, 25, 26
d 25, 26, 25 e 26, 25, 26 _____ 13

(14). 60 55 51 49 40 37

a 57, 45, 43 b 59, 45, 42 c 58, 46, 42
d 58, 45, 42 e 56, 46, 41 _____ 14

(15). 48 44 41 36 34 28

a 46, 38, 31 b 45, 39, 30 c 46, 39, 31
d 47, 38, 42 e 47, 39, 30 _____ 15

TEST 6.

Directions: Work these problems on a blank sheet of paper. Write the letter of the answer on the line to the right. The correct answer for the first problem (A) is b.

- A. If a man earned \$25.00 and spent \$10.00, how much money did he have left?
Ans.: a \$5 b \$15 c \$20 d \$10 b A
1. How many picture post cards can you buy for 15 cents at the rate of 3 for 5 cents?
Ans.: a 9 b 3 c 15 d 34 _____ 1
2. How many feet of railroad track can be laid with 750 ties if 25 ties are needed for each 50 feet?
Ans.: a 1250 b 1500 c 325 d 30 _____ 2
3. What number if multiplied by 3, is 2 times 9?
Ans.: a 3 b 9 c 18 d 6 _____ 3
4. A sample rug is 12 inches long and 9 inches wide. How long will a larger rug of the same proportions be if it is 36 inches wide?
Ans.: a 108 in. b 48 in. c 15 in. d 36 in. _____ 4
5. What is the number which if divided by 4, is $\frac{1}{8}$ of 72?
Ans.: a 12 b 18 c 48 d 3 _____ 5
6. A high school student borrowed \$75.00 for one year at 6% to start a chicken ranch. How many little chickens must he sell at 10 cents each to pay back the money he borrowed with interest?
Ans.: a 45 b 450 c 750 d 795 _____ 6
7. A dealer allowed an old customer a discount of 10% on the marked price of book cases. What is the marked price of a book case for which this customer paid him \$36.00?
Ans.: a \$40 b \$32.40 c \$3.60 d \$39.60 _____ 7
8. A circular flower bed 7 feet in diameter is to be bordered by plants set one foot apart. What will be the cost of the plants at the rate of 2 for 15 cents? (Circumference of a circle is about $3\frac{1}{2}$ times the diameter.)
Ans.: a 52¢ b \$1.65 c 70¢ d \$1.57 $\frac{1}{2}$ _____ 8
9. A man placed four stepping stones one foot square in a row in a section of his garden so that there were equal spaces on all four sides of each of the stones. If the section was 3 feet wide, how long was it?
Ans.: a 12 ft. b 3 ft. c 9 ft. d 8 ft. _____ 9
10. Ben lives 1.5 miles east of the library. James lives 2.5 miles directly west of the library. On a scale of $\frac{1}{2}$ inch = 1 quarter mile, how many inches will represent the distance between the boys' houses?
Ans.: a 8 in. b 16 in. c 6 in. d 2 in. _____ 10
11. What is the number which if added to 5 is 3 less than $\frac{1}{3}$ of $\frac{3}{5}$ of 60?
Ans.: a $\frac{1}{2}$ b 9 c 4 d 12 _____ 11
12. A gallon of water weighs 8.4 pounds. A gallon of gasoline weighs 68 per cent as much as a gallon of water. A pilot flying the air mail carried 50 gallons. How many pounds did this gasoline weigh?
Ans.: a 285 b 285.6 c 278.6 d 380 _____ 12
13. A coffee shop buys a blend of coffee composed of $\frac{2}{3}$ of Grade A at 60 cents a pound and $\frac{1}{3}$ of Grade B at 30 cents a pound. If they change the mixture, using $\frac{1}{3}$ of Grade A and $\frac{2}{3}$ of Grade B, how much will they save on every 10 pounds of coffee?
Ans.: a 3¢ b 10¢ c 30¢ d \$1.00 _____ 13
14. A man's will provides that his estate of \$15,000.00 should be divided as follows: $\frac{2}{5}$ to his wife and $\frac{1}{5}$ each to three children, except that in the event any of the children were deceased, their share should be divided equally between the remaining children and the wife. Two children were killed in an automobile accident. How much did the remaining child receive from the estate?
Ans.: a $\frac{1}{5}$ b \$6000.00 c \$4500 d \$5000 _____ 14
15. If a set of tires for one automobile costs one-half of what a set costs for another automobile; and if three sets of the cheaper tires last only as long as two sets of the more expensive kind, the total cost of the cheaper tires during a given period will average what fraction or per cent of the cost of the more expensive kind?
Ans.: a $\frac{1}{3}$ or 33 $\frac{1}{3}$ % b $\frac{1}{2}$ or 50%
c $\frac{3}{4}$ or 75% d $1\frac{1}{2}$ % _____ 15

TEST 7.

Directions: Draw a line under the word which means the same or about the same as the word. Write the number of this word on the line to the right, as:

- | | | | | | | |
|------------------|----------------|----------------|----------------|-----------------|---|----|
| 0. blossom | 1 tree | 2 vine | 3 flower | 4 garden | 3 | 0 |
| 1. inefficient | 1 avoidable | 2 quarrelsome | 3 incompetent | 4 unruly | | 1 |
| 2. confiscate | 1 assert | 2 seize | 3 compile | 4 comfort | | 2 |
| 3. malign | 1 insure | 2 muffle | 3 slander | 4 invade | | 3 |
| 4. whimsical | 1 accurate | 2 fashionable | 3 weighty | 4 fanciful | | 4 |
| 5. avarice | 1 virtue | 2 prominence | 3 greed | 4 honor | | 5 |
| 6. eradicate | 1 destroy | 2 vacate | 3 use | 4 solve | | 6 |
| 7. impeachment | 1 precedent | 2 settlement | 3 resignation | 4 accusation | | 7 |
| 8. discordant | 1 clashing | 2 despondent | 3 unsteady | 4 distinctive | | 8 |
| 9. titanic | 1 reddish | 2 acid | 3 large | 4 ancient | | 9 |
| 10. edict | 1 decree | 2 diction | 3 sovereign | 4 edition | | 10 |
| 11. recumbent | 1 cumbersome | 2 curved | 3 reclining | 4 saving | | 11 |
| 12. caprice | 1 action | 2 whim | 3 capture | 4 tact | | 12 |
| 13. expedite | 1 expel | 2 dictate | 3 delay | 4 hasten | | 13 |
| 14. loquacious | 1 talkative | 2 logical | 3 legal | 4 delicious | | 14 |
| 15. idiosyncrasy | 1 irritability | 2 peculiarity | 3 office | 4 imbecility | | 15 |
| 16. perfidious | 1 treacherous | 2 fragrant | 3 studious | 4 responsible | | 16 |
| 17. artifice | 1 artless | 2 hate | 3 definition | 4 device | | 17 |
| 18. anomaly | 1 ceremony | 2 illness | 3 irregularity | 4 normal | | 18 |
| 19. reciprocal | 1 charming | 2 mutual | 3 agreeable | 4 meditative | | 19 |
| 20. travesty | 1 burlesque | 2 tragedy | 3 meeting | 4 hotel | | 20 |
| 21. obtuse | 1 pointed | 2 reversible | 3 blunt | 4 objectionable | | 21 |
| 22. abstemious | 1 stormy | 2 excessive | 3 mournful | 4 temperate | | 22 |
| 23. tangent | 1 blend | 2 agent | 3 touching | 4 sensing | | 23 |
| 24. extraneous | 1 extra | 2 foreign | 3 transparent | 4 noisy | | 24 |
| 25. erudite | 1 crude | 2 learned | 3 rugged | 4 polite | | 25 |
| 26. ameliorate | 1 improve | 2 harden | 3 dilute | 4 decorate | | 26 |
| 27. malapert | 1 sick | 2 lazy | 3 slow | 4 saucy | | 27 |
| 28. opulence | 1 jewel | 2 generosity | 3 wealth | 4 honor | | 28 |
| 29. urbanity | 1 loyalty | 2 refinement | 3 weakness | 4 barbarism | | 29 |
| 30. propinquity | 1 nearness | 2 curiosity | 3 diligence | 4 propriety | | 30 |
| 31. trajectory | 1 court | 2 project | 3 area | 4 curve | | 31 |
| 32. corollary | 1 crown | 2 inference | 3 enclosure | 4 supersede | | 32 |
| 33. ostensible | 1 actual | 2 available | 3 genuine | 4 pretended | | 33 |
| 34. salient | 1 salty | 2 outstanding | 3 merciful | 4 agreeable | | 34 |
| 35. probity | 1 uprightness | 2 interference | 3 suspicion | 4 weight | | 35 |
| 36. acephalous | 1 false | 2 warlike | 3 headless | 4 sensible | | 36 |
| 37. porphyry | 1 papyrus | 2 rock | 3 cave | 4 manuscript | | 37 |
| 38. strident | 1 muscular | 2 shrill | 3 battered | 4 strong | | 38 |
| 39. effete | 1 exhausted | 2 festive | 3 fragile | 4 plentiful | | 39 |
| 40. tyro | 1 scold | 2 village | 3 law | 4 beginner | | 40 |
| 41. perimeter | 1 measure | 2 instrument | 3 boundary | 4 difficulty | | 41 |
| 42. diurnal | 1 seasonable | 2 occasional | 3 timely | 4 daily | | 42 |
| 43. obloquy | 1 disaster | 2 blame | 3 pride | 4 obligation | | 43 |
| 44. eyot | 1 island | 2 lake | 3 river | 4 insect | | 44 |
| 45. detritus | 1 fossil | 2 dextrous | 3 fragment | 4 poem | | 45 |
| 46. palladium | 1 burden | 2 safeguard | 3 title | 4 residence | | 46 |
| 47. quiddity | 1 oddity | 2 doubt | 3 essence | 4 presence | | 47 |
| 48. ambient | 1 uncertain | 2 surrounding | 3 surprising | 4 well-wishing | | 48 |
| 49. orrery | 1 book | 2 prophecy | 3 apparatus | 4 error | | 49 |
| 50. syzygy | 1 separation | 2 choice | 3 conjunction | 4 nonsense | | 50 |



THE UNITED STATES ARMED FORCES INSTITUTE

Examination in SENIOR SCIENCE—High-School Level

Form SSrS—I-B-4

DIRECTIONS: You have two hours for this examination. As you answer the questions, you should omit any that seem unusually difficult until you finish the others.

Your answers to the exercises in this examination are to be recorded on the separate ANSWER SHEET which is loosely inserted in this examination booklet. **Remove this answer sheet now;** write your name and the other information called for in the blanks at the top of the answer sheet; then finish reading these directions.

After the number on the answer sheet corresponding to that of each exercise, mark the **one** lettered space which designates the answer you have selected as correct. If your answer sheet contains rows of squares, indicate each answer with a cross (X), for example,

A	B	C	D	E
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If your answer sheet contains rows of paired dotted lines, indicate each answer with a **heavy black mark** with the special pencil, for example,

A	B	C	D	E

Avoid resting the point of your pencil on the answer sheet while you are considering your answer. Do not make unnecessary marks. If you change an answer, erase your first mark completely. Do not fold or crease your answer sheet.

EXAMPLES

0. A meter measures

A. density

D. weight

B. area

E. volume

C. distance

[Since the correct answer is distance, C would be marked on the answer sheet.]

00. The number of feet in a yard is

A. 2

D. 8

B. 4

E. none of these answers

C. 6

[Since the correct answer, 3, is not given, E would be marked on the answer sheet.]

Prepared by the

EXAMINATIONS STAFF FOR THE UNITED STATES ARMED FORCES INSTITUTE

Published by

THE AMERICAN COUNCIL ON EDUCATION

Distributed by

THE AMERICAN COUNCIL ON EDUCATION
15 Amsterdam Avenue, New York 23

SCIENCE RESEARCH ASSOCIATES
228 South Wabash Avenue, Chicago 4

Copyright, 1944

THE AMERICAN COUNCIL ON EDUCATION
SECOND PRINTING

ORDER NO. 616

SECTION I

Basic Information

1. What percentage of oxygen does air normally contain at sea level?
 A. About 95% B. About 80% C. About 50% D. About 20% E. About 5%

2. Which of the following substances is composed primarily of sodium carbonate?
 A. Washing soda B. Brine C. Fool's gold D. Chalk E. Quartz

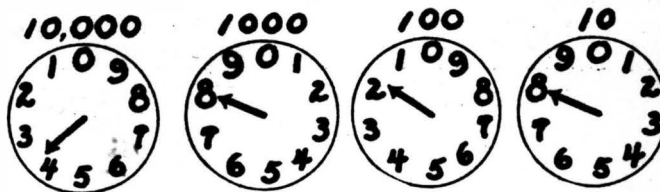
3. What percentage of an 18-carat gold ring is pure gold?
 A. 75% B. 67% C. 50% D. 33% E. 25%

4. Which of the following substances is commonly used in many households to soften hard water?
 A. Table salt B. Washing soda C. Alum D. Plaster of Paris E. Flour

5. What is the reading of the kilowatt-hour meter illustrated?

- A. 4,818
B. 4,828

- C. 3,818
D. 3,828



6. Which of the following is a symbol for resistance?

A.

B.

C.

D.

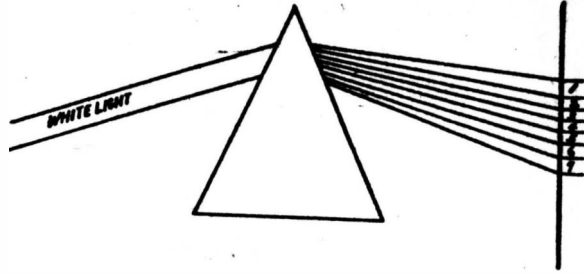
E.

7. For what is an electric transformer commonly used?

- A. To increase the wattage of direct current
- B. To increase the wattage of alternating current
- C. To increase or decrease the voltage of alternating current
- D. To change alternating current to direct current
- E. To change direct current to alternating current

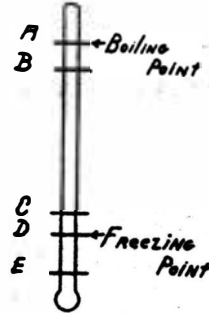
8. When white light enters a prism it is split into seven colors which are spread out over the range indicated from 1 to 7. What color would appear at 1?

A. Blue
B. Violet
C. Red
D. Orange
E. Yellow



9. At what point on the temperature scale is water the most dense?

A. At A B. At B C. At C D. At D E. At E



10. What is the approximate speed of light waves?

A. 93,000,000 miles per second
B. 186,000 miles per second
C. 1,100 miles per second
D. 1,100 feet per second
E. None of these

11. Which of the following statements is true?

A. An atom of sulfur has the same weight as an atom of sodium.
B. All elements are able to combine chemically with oxygen.
C. A compound is formed whenever two or more elements mix.
D. A molecule of water has all the properties of hydrogen and oxygen.
E. An atom of oxygen is not the same as a molecule of oxygen.

12. What is meant by a British Thermal Unit?

A. The heat necessary to raise the temperature of one pound of water one degree Fahrenheit
B. The heat necessary to raise the temperature of one pound of any substance one degree Fahrenheit
C. The heat necessary to change one pound of ice to liquid water
D. The heat necessary to change one pound of any substance to a liquid
E. The heat necessary to evaporate one pound of any substance

13. A rise of one degree on the Fahrenheit scale is equal to how much of a rise on the centigrade scale?

A. $\frac{1}{9}$ of a degree
B. $\frac{2}{9}$ of a degree
C. $\frac{5}{9}$ of a degree
D. $1\frac{4}{9}$ or $1\frac{4}{9}$ of a degree
E. $2\frac{2}{9}$ or $1\frac{4}{9}$ of a degree

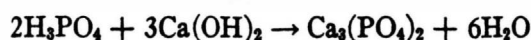
14. Which of the following measures most accurately describes a centimeter?

- A. Slightly less than $\frac{1}{2}$ inch
- B. Slightly more than $\frac{1}{2}$ inch
- C. Slightly less than 1 foot
- D. Slightly more than 17 inches
- E. Slightly more than 1 yard

15. Which of the following measures is equivalent to 1,000 milliliters?

- A. One centiliter
- B. One deciliter
- C. One hectoliter
- D. One kiloliter
- E. One liter

16. According to the equation given, how many atoms of calcium are contained in one molecule of calcium hydroxide?



- A. 1
- B. 2
- C. 3
- D. 5
- E. 6

17. Which of the following best describes an electron?

- A. It is a neutrally charged particle with a mass similar to that of the hydrogen atom.
- B. It is a negatively charged particle with a mass much less than that of the hydrogen atom.
- C. It is a negatively charged particle with a mass similar to that of the hydrogen atom.
- D. It is a positively charged particle with a mass similar to that of the hydrogen atom.
- E. It is a positively charged particle with a mass much less than that of the hydrogen atom.

18. Which of the substances—water, air, and carbon—are compounds?

- A. All three
- B. Only air and carbon
- C. Only water and carbon
- D. Only water
- E. Only carbon

19. How many chemical compounds are there?

- A. About 57
- B. About 92
- C. About 254
- D. about 512
- E. More than 10,000

20. Which of the following elements will not combine or react chemically with another element?

- A. Hydrogen
- B. Sodium
- C. Radium
- D. Chlorine
- E. Neon

21. What color does litmus paper turn in an acid solution?

- A. White
- B. Blue
- C. Red
- D. Green
- E. Yellow

22. In the formula H_2SO_4 , what does the symbol **S** stand for?

- A. Sulfur B. Sulfite C. Sulfate D. Sulfide E. Sodium

23. A black tarnish forms on a silver fork when it is used with a hard-boiled egg. What element present in the egg causes this reaction?

- A. Iron B. Sulfur C. Phosphorus D. Calcium E. Carbon

24. How is most iron produced commercially from its ore?

- A. By reducing it with coke in a furnace
B. By roasting it in air
C. By an electrolytic process
D. By distillation at a very high temperature
E. By a replacement reaction in which any very active metal such as sodium is employed

25. Which of the following best describes hydration?

- A. The absorption of water
B. The decomposition of water into its elements
C. A chemical combination of a substance with water
D. A chemical combination of a substance with hydrogen
E. A chemical reaction in which hydrogen is liberated

26. What metal is commonly alloyed with gold to give it the hardness needed in making jewelry?

- A. Aluminum B. Copper C. Magnesium D. Chromium E. Mercury

27. What element does protein always contain that carbohydrate and fat do not?

- A. Hydrogen B. Carbon C. Nitrogen D. Phosphorus E. Sulfur

28. What acid when added to a protein causes it to turn yellow?

- A. Sulfuric acid D. Phosphoric acid
B. Nitric acid E. Carbonic acid
C. Hydrochloric acid

29. Which of the following elements helps in the formation of hemoglobin in the blood?

- A. Calcium B. Copper C. Iron D. Iodine E. Phosphorus

30. How does the number of Calories required by a growing boy generally compare with those required by an adult if both are doing the same kind of work?
- They both require about the same.
 - The growing boy will require more.
 - The growing boy will require less.
 - It is impossible to generalize.
31. Which of the following will prevent scurvy?
- Vitamin A
 - Thiamin (B_1)
 - Vitamin C
 - Vitamin D
 - Riboflavin (B_2 or G)
32. Which of the following is produced by the chemical treatment of cellulose?
- Rayon
 - Silk
 - Cotton
 - Linen
 - Worsted wool
33. What name is given to an expert on weather and weather-forecasting?
- Geologist
 - Astrologist
 - Meteorologist
 - Archeologist
 - Metallurgist
34. Which of the following heavenly bodies comes closest to the earth?
- Mercury
 - Venus
 - The sun
 - Mars
 - Jupiter
35. Which of the following is a measure of volume?
- Liter
 - Kilogram
 - Centimeter
 - Milligram
 - Hectare
36. Which of the following will melt the greatest amount of ice?
- Two pounds of iron at 400°F .
 - Two pounds of copper at 400°F .
 - Two pounds of lead at 400°F .
 - Two pounds of water at 211°F .
 - One pound of steam at 213°F .
37. What is the principal advantage of the "electron microscope" over the ordinary "compound microscope"?
- The electron microscope is easier to adjust.
 - The electron microscope has greater magnifying power.
 - The electron microscope is easier to use on moving objects.
 - The electron microscope obtains a photograph of each observation.
 - The electron microscope is more rugged in construction and design and will withstand considerable abuse.
38. What very serious disease is contracted by eating uncooked meat, such as pork, which contains a wormlike parasite?
- Anthrax
 - Bubonic plague
 - Tetanus
 - Trichinosis
 - Diphtheria

39. What is the approximate speed of sound waves?

- A. 186,000 miles per second
- B. 186,000 feet per second
- C. 1,100 miles per second
- D. 1,100 feet per second
- E. None of these

40. Which of the following best describes the air when its relative humidity is 50%?

- A. One cubic centimeter of air contains one-half cubic centimeter of moisture.
- B. One cubic centimeter of air contains one gram of water.
- C. One gram of air contains one-half gram of water.
- D. The air contains as much water vapor as it can hold (at that particular temperature) without condensation's taking place.
- E. The air contains half as much water vapor as it can hold (at that particular temperature) without condensation's taking place.

41. In which of the following instances is heating accomplished primarily by convection?

- A. Heating a dry pan on a hot stove
- B. Heating the room with a hot-water radiator
- C. Heating the coils of a toaster with electric current
- D. Heating the earth with the sun's energy
- E. Heating a rock by rubbing it vigorously with another rock

42. In most parts of the earth a magnetic compass does not point toward the true geographic North. What name is given to the angle between the direction which the compass points and the true geographic North?

- A. Inclination
- B. Declination
- C. Dip
- D. Distortion
- E. Hysteresis

43. Which of the following foods contains the highest percentage of protein?

- A. White bread
- B. Lean beef
- C. Spinach
- D. Doughnuts
- E. Oranges

44. What is the line on a weather map which connects points having the same temperature?

- A. Isocline
- B. Isotherm
- C. Isobar
- D. Isosceles
- E. Isotope

45. Which of the following is an example of oxidation?

- A. The conversion of ore to metal
- B. The burning of wood
- C. The dissolving of oxygen in water
- D. The condensation of liquid oxygen from the gas
- E. The conversion of liquid oxygen to gaseous oxygen

46. What is "pasteurization"?

- A. A treatment under high pressure
- B. A treatment in a vacuum or under low pressure
- C. A treatment under elevated temperatures
- D. A treatment under refrigerating conditions
- E. Any treatment designed to purify food

47. By which of the following processes does an electric refrigerator actually produce the cooling effect?

- A. By condensing a gas
- B. By evaporating a liquid
- C. By compressing a gas
- D. By compressing a liquid
- E. By rapidly circulating a gas through a liquid

48. What happens as the ice in a lake melts?

- A. The ice always gives off heat.
- B. The ice always absorbs heat.
- C. The ice neither absorbs nor gives off heat during this change.
- D. The ice usually (but not always) gives off heat during this change.
- E. The ice usually (but not always) absorbs heat during this change.

49. For what is an electric generator used?

- A. To convert electrical energy into mechanical energy
- B. To convert mechanical energy into electrical energy
- C. To convert chemical energy into electrical energy
- D. To convert electrical energy into chemical and mechanical energy
- E. To convert mechanical energy into light and chemical energy

50. Which of the following waves is least like the waves sent out by a broadcasting station?

- A. X-rays
- B. Sound waves
- C. Light waves
- D. Ultra-violet rays
- E. Infra-red rays

51. What is the principal reason that an object will weigh less on a high mountain than it does at sea level?

- A. Because the atmospheric pressure is different
- B. Because the distance from the earth's center is different
- C. Because the mass of the object is different
- D. Because the humidity is different
- E. Because the centrifugal force is different

52. What is the source of practically all of our energy?

- A. Coal
- B. Microorganisms
- C. Petroleum
- D. Heat inside the earth
- E. The sun

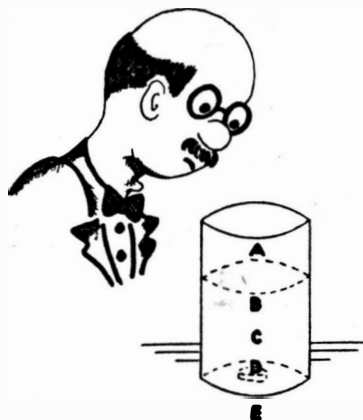
53. In an ordinary snapshot or photograph, of what is the black substance composed?

- A. Graphite
- B. Copper oxide
- C. Silver
- D. Charcoal
- E. India ink

SECTION II

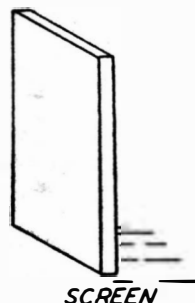
Application of Principles

54. In which of the following solutions would a block of wood float with more of its surface exposed than it would in any of the others?
- Salt water near its boiling point
 - Salt water near its freezing point
 - Pure water near its boiling point
 - Pure water near its freezing point
55. Light bulb A casts as much illumination on a wall one foot away as light bulb B does when it is two feet away. How much brighter is bulb B than bulb A?
- $1\frac{1}{2}$ times as bright as A
 - 2 times as bright as A
 - 3 times as bright as A
 - 4 times as bright as A
 - 8 times as bright as A
56. A man sees a coin which has been dropped in a can of water. As he looks over the edge of the can, where does the coin appear to be?
- Position A
 - Position B
 - Position C
 - Position D
 - Position E



57. What process takes place when a film or photograph is "developed"?
- The image is brought out or made visible.
 - The image is made softer so that there is less contrast.
 - The color of the image is changed from brown to black.
 - The color of the image is changed from black to some other color.
 - The sensitive material which has not been converted to silver is dissolved.
58. If the image from a neon sign in the form of the letter *F* is focused on a screen, in what position will the image appear if the sign is a great distance from the convex lens?

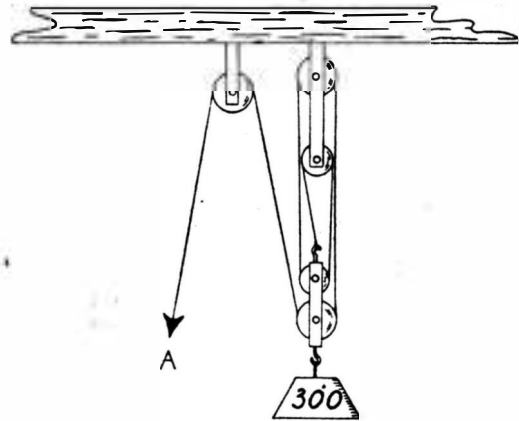
-
-
-
-
- None of these



59. How will the speed of a chemical reaction be affected if the temperature is raised from 10°C . to 20°C .?
- A. It will react more slowly.
 - B. It will react at about the same rate.
 - C. It will react about twice as fast.
 - D. It will react about ten times as fast.
 - E. It will react about one hundred times as fast.

60. How will the boiling point of a gallon of water be affected by dissolving a small amount of sugar in it?
- A. It will be slightly raised.
 - B. It will remain unchanged.
 - C. It will be slightly lowered.

61. How much force must be applied downward at *A* in order to keep the 300-pound weight from falling? (Disregard the weight of the pulleys and the rope.)
- A. 100 pounds
 - B. 75 pounds
 - C. 60 pounds
 - D. 50 pounds
 - E. None of these



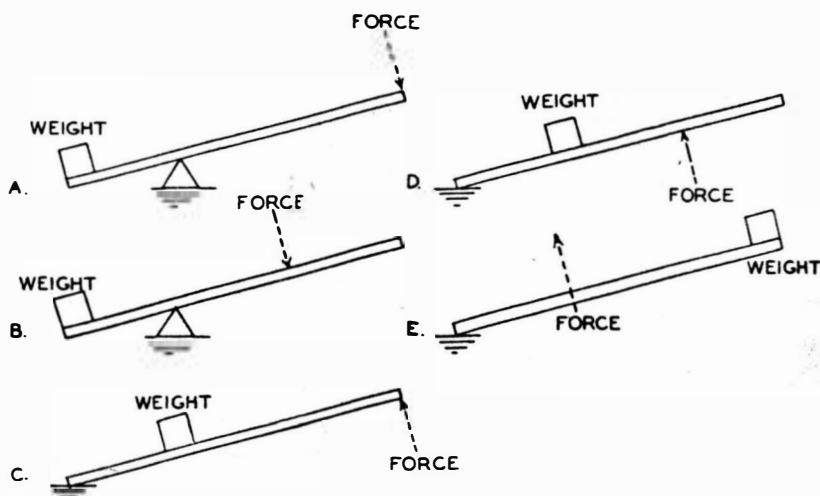
62. What is the efficiency of an electric motor which performs work equivalent to 2 horsepower and consumes electricity at the rate of 3 horsepower?
- A. $33\frac{1}{3}\%$
 - B. 44%
 - C. 50%
 - D. $66\frac{2}{3}\%$
 - E. Impossible to tell from the information available
63. Under which of the following conditions will a can of hot beans cool most slowly?
- A. When surrounded by water (at room temperature)
 - B. When surrounded by a liquid having a low density (at room temperature)
 - C. When surrounded by still air (at room temperature)
 - D. When surrounded by a vacuum
 - E. When surrounded by glass wool and air (at room temperature)

64. Under which of the following conditions will a piece of paper scorch or catch fire most easily when placed in a flame?
- A. When a copper rod is wrapped in the paper
 - B. When a silver rod is wrapped in the paper
 - C. When a large stone is wrapped in the paper
 - D. When a block of wood is wrapped in the paper
 - E. When the paper is made into a sack and filled with water
65. Cup A contains 100 grams of water at 90°C . and cup B contains 50 grams of water at 90°C . As both cups of water cool to 20°C ., how does the amount of heat lost by the water in each compare?
- A. Both lose the same amount.
 - B. The water in A loses twice as much.
 - C. The water in B loses twice as much.
 - D. The water in A loses four times as much.
 - E. The water in B loses four times as much.
66. A stoppered bottle, half full of water, contains air which was sealed in at room temperature and at sea level. At sea level will the water in this bottle boil at the same temperature as water in a half-filled bottle which is not stoppered?
- A. Yes, at the same temperature.
 - B. No, that in the stoppered bottle will boil at a higher temperature.
 - C. No, that in the stoppered bottle will boil at a lower temperature.
67. Automobile tires containing which of the following will provide the most comfortable ride?
- A. Tires filled with water
 - B. Tires filled with alcohol
 - C. Tires filled with a gas
 - D. Tires filled with water in which there is much dissolved gas
 - E. When there is a vacuum in the tires
68. Would a skyrocket operate in space where there is no air?
- A. No, for there is no air against which the propelling force can push.
 - B. No, for the propelling gases would undoubtedly expand in all directions.
 - C. Yes, it would operate as well or better than it would in air.
 - D. Yes, but it would just barely move.
 - E. It is impossible to tell from the information available.
69. How does the sound produced by a long harp string compare with that produced by a short harp string if the tensions on both are the same and if they are plucked in the same manner?
- A. The sound from the longer one is much louder.
 - B. The sound from the shorter one is much louder.
 - C. The sound from the longer one is clearer.
 - D. The sound from the longer one is higher pitched.
 - E. The sound from the shorter one is higher pitched.

70. How will the pitch of a factory whistle sound to a man who drives his car rapidly and at a constant rate of speed past the tower on which the whistle is located?
- The pitch will rise steadily.
 - The pitch will fall and then rise.
 - The pitch will rise and then fall.
 - The pitch will remain practically constant as he approaches the tower and fall to a new level as he passes the tower.
 - The pitch will remain practically constant as he approaches the tower and rise to a new level as he passes the tower.
71. An observer on the ground hears an airplane flying rapidly at high altitude. Judging by the sound, where will the plane appear to be?
- Ahead of its true location
 - At its true location
 - To the rear of its true location
 - Either at its true location or slightly to one side
 - To one side of its true location

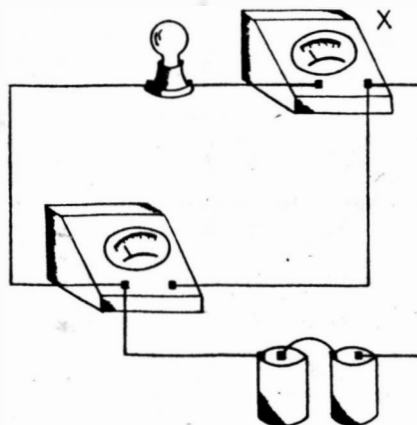
72. In which of the following situations will the least amount of force be required to move the weight?

- In situation A
- In situation B
- In situation C
- In situation D
- In situation E



73. Meter X is probably what kind of a meter?

- An ohmmeter
- An ammeter
- A voltmeter
- A wattmeter
- A coulometer



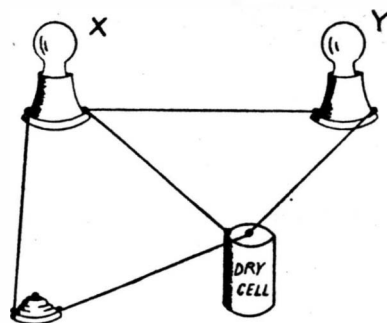
74. Which of the following sources along with suitable resistances might be used to supply alternating current for a tiny bulb?

- (1) A charged storage battery
- (2) A group of dry cells
- (3) A transformer connected to a household electric outlet

- A. Any one of the three
- B. Only number 2 or number 3
- C. Only number 3
- D. Only number 1
- E. Only number 2

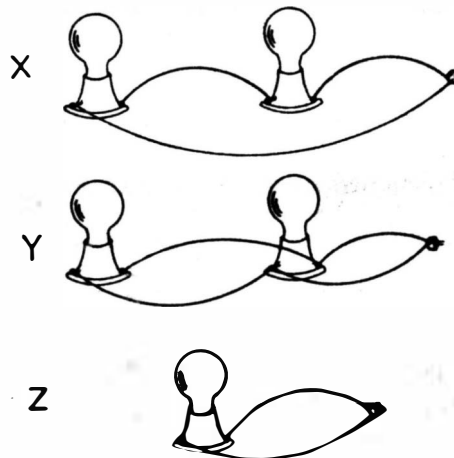
75. In this circuit in which two light bulbs, one ordinary bell push button, and one dry cell are connected, what will happen?

- A. Both bulbs are lighted all the time, and the push button has no effect.
- B. Both bulbs are lighted all the time, and bulb *X* goes out as the button is pushed.
- C. Bulb *X* is lighted all the time, and bulb *Y* lights as the button is pushed.
- D. Bulb *Y* is lighted all the time, and bulb *X* lights as the button is pushed.
- E. Both bulbs light as the button is pushed.



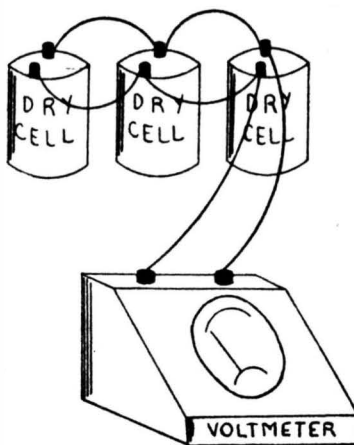
76. All the light bulbs in the accompanying circuits are 50-watt bulbs. In which of the three circuits will the least amount of electric power be consumed when the plug is inserted in a household electrical outlet?

- A. Circuit *X* will consume the least amount.
- B. Circuit *Y* will consume the least amount.
- C. Circuit *Z* will consume the least amount.
- D. Circuits *X* and *Y* will consume the same amount while *Z* will consume more than either *X* or *Y*.
- E. It is impossible to tell from the information available.



77. Three dry cells are connected in the manner shown. What voltage will be registered by the voltmeter? (The voltage of each cell is $1\frac{1}{2}$ volts.)

- A. Zero volts
- B. $1\frac{1}{2}$ volts
- C. 3 volts
- D. $4\frac{1}{2}$ volts
- E. None of these



78. What happens when a glass rod is rubbed with a piece of silk?

- A. Electrons are passed from one to the other.
- B. Protons are passed from one to the other.
- C. Electrons and protons exchange places.
- D. Electrons and neutrons exchange places.
- E. Protons and neutrons exchange places.

79. If there is a complete combustion of the substance C_8H_{18} in air, how many new compounds will be formed?

- A. One
- B. Two
- C. Three
- D. Four or more
- E. Impossible to tell from the information available

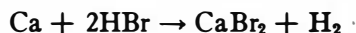
80. What is one product of the reaction when potassium chlorate and manganese dioxide are heated together?

- A. Hydrogen chloride
- B. Oxygen
- C. Ozone
- D. Chlorine
- E. Chlorine oxide

81. When chlorine has a valence of +7 and oxygen has a valence of -2, what will be the formula for this oxide of chlorine?

- A. $9ClO$
- B. $7ClO_2$
- C. $7Cl_2O$
- D. Cl_7O_2
- E. Cl_2O_7

82. The following equation describes the reaction between calcium and hydrobromic acid:



How many pounds of hydrobromic acid are required to react with 40 pounds of calcium? (Atomic weights: H = 1, Br = 80, Ca = 40)

- A. $40\frac{1}{2}$ pounds
- B. 81 pounds
- C. 162 pounds
- D. 404 pounds
- E. None of these amounts

83. What products are formed when ammonium hydroxide and hydrochloric acid react chemically?

- A. Ammonia and water
- B. Ammonia, chlorine, and water
- C. Ammonium chloride and water
- D. Ammonium chloride and chlorine
- E. Ammonium chloride, chlorine, and water

84. What is one of the properties of elements whose neutral atoms contain one electron in the outer orbit?

- A. These elements have a valence of one.
- B. These elements have a valence of seven.
- C. These elements are nonmetals.
- D. These elements will not combine chemically with any other element.
- E. These elements are gases at room temperature.

85. On which of the electrodes will sodium be formed from a molten solution of sodium chloride?

- A. Sodium will be formed at the positive electrode only.
- B. Sodium will be formed at the negative electrode only.
- C. Some sodium will be formed at both electrodes but most of it will be formed at the negative electrode.
- D. Some sodium will be formed at both electrodes but most of it will be formed at the positive electrode.
- E. Approximately equal amounts of sodium will be formed at both electrodes.

86. The body temperature of a normal human adult is 98.6°F . To which of the following temperatures is this most nearly equal?

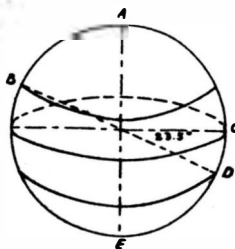
- A. 20°C .
- B. 30°C .
- C. 40°C .
- D. 60°C .
- E. 80°C .

87. Four identical rubber balloons, each filled with 5 cubic feet of hydrogen gas at 20°C ., are released on a warm, sunny day. Balloon A is painted a dull black color; balloon B is painted a shiny black color; balloon C is painted a dull silver color; and balloon D is painted a shiny silver color. Which will expand the least due to the heat from the sun?

- A. Balloon A
- B. Balloon B
- C. Balloon C
- D. Balloon D
- E. None, for all will expand equally

88. What is the polarity of an electric cell made by placing strips of zinc and carbon in a weak acid solution? (Zinc is chemically very active and carbon is relatively inactive.)

- A. The zinc electrode is negative and the carbon electrode is positive.
- B. The carbon electrode is negative and the zinc electrode is positive.
- C. Both electrodes are positive.
- D. The zinc electrode changes back and forth from positive to negative while the carbon remains neutral.
- E. The carbon electrode changes back and forth from positive to negative while the zinc electrode remains neutral.

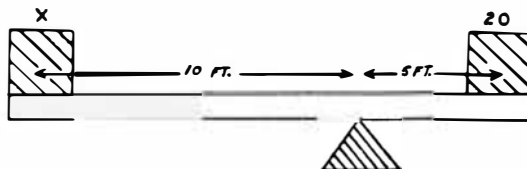
89. What is the resistance of an electric toaster through which 5 amperes of current flow when it is connected to a 110-volt source?
- A. $\sqrt{22}$ ohms or 4.69 ohms
 B. 22 ohms
 C. 550 ohms
 D. 2,750 ohms
 E. None of these
90. How does the work accomplished by a man who climbs a ladder leading to a platform 10 feet above the ground compare with the work he does in walking up a gradual incline 30 feet long which leads to this same platform?
- A. He performs 9 times as much work in climbing the ladder.
 B. He performs 3 times as much work in climbing the ladder.
 C. He performs the same amount of work in each case.
 D. He performs $\frac{1}{3}$ as much work in climbing the ladder.
 E. He performs $\frac{1}{9}$ as much work in climbing the ladder.
91. Which of the following is responsible for most contagious diseases?
- A. A vitamin deficiency
 B. A mineral deficiency
 C. Glandular troubles
 D. An allergy to certain proteins
 E. One-celled plants and animals
92. In the diagram below, points *A*, *B*, *C*, *D*, and *E* represent five different observers on the surface of the earth. The line between *A* and *E* represents the earth's axis, with *A* at the North Pole. To which of the observers on the earth's surface does the sun appear directly overhead at noon on March 21?
- A. To a person at *A*
 B. To a person at *B*
 C. To a person at *C*
 D. To a person at *D*
 E. To a person at *E*
- 
93. As a candle weighing 23 grams burns, it reacts with 80 grams of oxygen in the air. How much will the various substances weigh which are formed by this burning?
- A. Less than 23 grams
 B. Between 23 and 80 grams
 C. Between 80 and 103 grams
 D. Exactly 103 grams
 E. More than 103 grams
94. With what color ink should the white-paper label of a bottle be printed if the letters are not to be visible under a green light?
- A. Red
 B. Green
 C. Either red or green
 D. Black
 E. Some color other than the three named

95. A hot piece of aluminum when placed on a block of ice is able to melt 200 grams of ice, while a piece of iron having the same temperature and weight is able to melt only 100 grams. If it takes 22 calories to raise the temperature of this same piece of aluminum 10°C ., approximately how many calories will be required to raise the temperature of the piece of iron through the same number of degrees?

- A. About 44 B. About 22 C. About 11 D. About $5\frac{1}{2}$ E. None of these

96. What is the weight of the block at X if the seesaw balances?

- A. About 5 lb. D. about 40 lb.
B. About 10 lb. E. None of these
C. About 20 lb.



97. In a certain steam engine only about 10% of the energy from coal is actually converted into mechanical energy. Which of the following explains what happens to some of the remaining 90% of the coal's energy?

- (1) Some of the energy is destroyed.
- (2) Heat is created by friction in the bearings.
- (3) Heat from the boiler is transferred to the surrounding air.

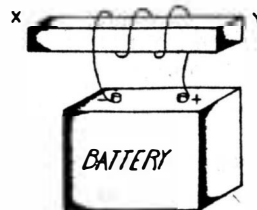
- A. All three D. Only number 1
B. Only number 1 and number 2 E. Only number 3
C. Only number 2 and number 3

98. What explanation is usually given for the fact that the distance from pole to pole is less than that directly through the earth at the equator?

- A. The rotation of the earth
B. The attraction of the sun
C. The attraction of the two magnetic poles of the earth
D. The combined forces of all the planets and stars
E. The tides and ocean currents

99. If current from a battery flows through the insulated wire wound around the iron bar XY, which of the following statements best describes the condition of the bar?

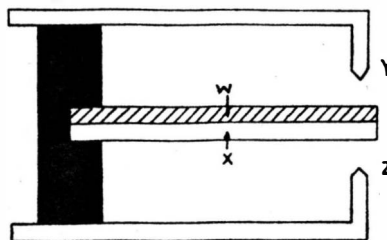
- A. The bar will become a magnet with one end a north pole and the other end a south pole.
B. The bar will become a magnet with both ends north poles.
C. The bar will become a magnet with both ends south poles.
D. The bar will become a magnet with first one end and then the other becoming the north pole.
E. One end of the bar will become magnetized and the other end will remain unmagnetized.



100. A six-foot man stands in front of a mirror that is 7 feet away from him. How far away from him will his own reflection appear to be?
- A. $3\frac{1}{2}$ feet away
B. 7 feet away
C. 14 feet away
D. 49 feet away
E. At some other distance

101. In the thermostat illustrated, metal *W* expands 0.00002 of its length for a one-degree increase in temperature while metal *X* expands 0.00005 of its length for each one-degree increase in temperature. When the room in which the thermostat is placed gets warmer, in what direction will the bar on the thermostat move?

- A. Toward *Y*
B. Toward *Z*
C. Will remain midway between *Y* and *Z*
D. Toward *X* and then back toward *Z*
E. Toward *Z* and then back toward *Y*



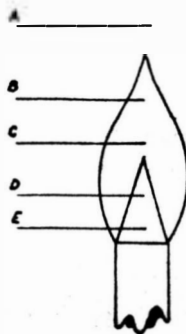
102. Which of the following principles best explains the operation of a fluorescent light?
- A. The light is produced as electric sparks jump from one end of the tube to the other.
B. The light is produced by the vigorous boiling of mercury.
C. The light is produced by the chemicals as electricity passes through them.
D. The light is produced by the chemicals as invisible ultra-violet rays fall on them.
E. The light is produced as invisible rays strike against the glass walls of the tube.
103. Ten seconds after a boy discharges his rifle, he hears the echo of its report coming from a distant hillside. Approximately how far away is the hillside?
- A. About $\frac{1}{2}$ mile
B. About 1 mile
C. About $1\frac{1}{2}$ miles
D. About 2 miles
E. More than 2 miles
104. In a reflecting telescope, is there any advantage in using a mirror 100 inches in diameter instead of a mirror 50 inches in diameter?
- A. No, a small mirror is best because it can be ground more accurately.
B. No, a small mirror is just as good as the large one; furthermore, it is less heavy and less expensive.
C. No, for the smaller mirror has greater magnifying power.
D. Yes, for the large mirror collects more light and makes the image brighter.
E. Yes, for the larger mirror has greater magnifying power.

105. In the ordinary telephone circuit, in what order do the following changes occur?

- A. Speech—to electrical impulses—to sound waves
- B. Speech—to magnetic impulses—to electrical impulses—to magnetic impulses—to sound waves
- C. Speech—to magnetic impulses—to sound waves
- D. Speech—to electrical impulses—to magnetic impulses—to sound waves
- E. Speech—to electrical impulses—to sound waves

106. Which region in or near the Bunsen burner flame is the hottest?

- A. Region A
- B. Region B
- C. Region C
- D. Region D
- E. Region E



107. What must you know about any block of wood in order to be able to predict whether it will float in water? (Assume that you know the necessary characteristics of water.)

- A. The size of the block
- B. The density of the block
- C. Both the size and the density of the block
- D. The weight of the block
- E. Both the weight and the density of the block

108. What occurs when a current passes through an ordinary copper wire?

- A. Electrons pass from atom to atom.
- B. Protons pass from atom to atom.
- C. Positrons pass from atom to atom.
- D. Neutrons pass from atom to atom.
- E. Atoms move from one end of the wire to the other.

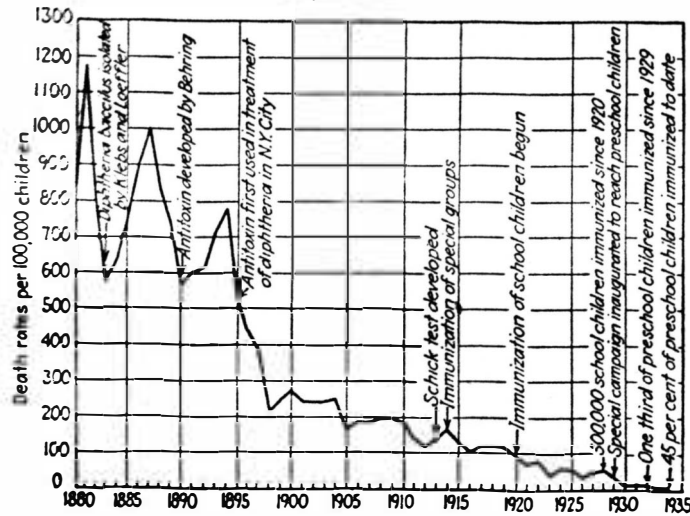
109. Certain incendiary bombs are composed of a magnesium shell and contain thermite, a mixture of powdered aluminum and iron oxide, which is set off by a percussion cap. Why is it that the burning thermite charge cannot be extinguished by smothering?

- A. The temperature is too high.
- B. The material is too finely divided.
- C. The aluminum does not react with oxygen.
- D. The reaction requires only a small amount of oxygen from the air.
- E. The aluminum reacts with the oxygen contained in the iron oxide.

SECTION III

Application of Scientific Method

DEATH RATE FROM DIPHTHERIA FOR CHILDREN
UNDER TEN YEARS OF AGE, NEW YORK CITY
1880-1934



For each of the following items 110-13, mark answer space

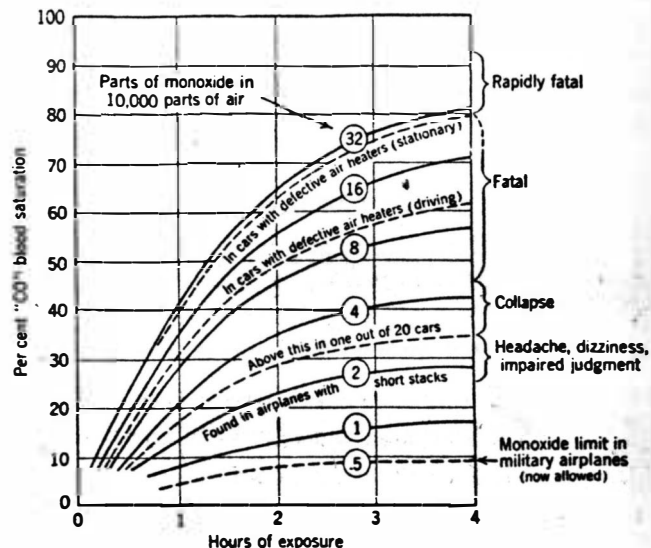
- A. if the data support the statement
- B. if the data contradict the statement
- C. if the data neither support nor contradict the statement

110. In 1930 more people in New York City died from diphtheria than in 1915.
111. After the diphtheria germ was discovered, the yearly death rate due to diphtheria among New York City children under ten years of age was always lower than during the previous years.
112. After the immunization of New York City school children began, there was a general decline in the death rate from diphtheria in this city among children under ten years of age.
113. The epidemic in 1894 was more serious than the one in 1887.

The graph shown indicates the effects of inhaling carbon monoxide. In each of the items 114-20 mark answer space

- A. if the data support the statement
- B. if the data contradict the statement
- C. if the data neither support nor contradict the statement

114. The maximum amount of carbon monoxide allowed in military airplanes is less than 1 part in 10,000 parts of air.
115. The air in cars with defective air heaters contains a greater amount of carbon monoxide when the car is in motion than when it is stationary.



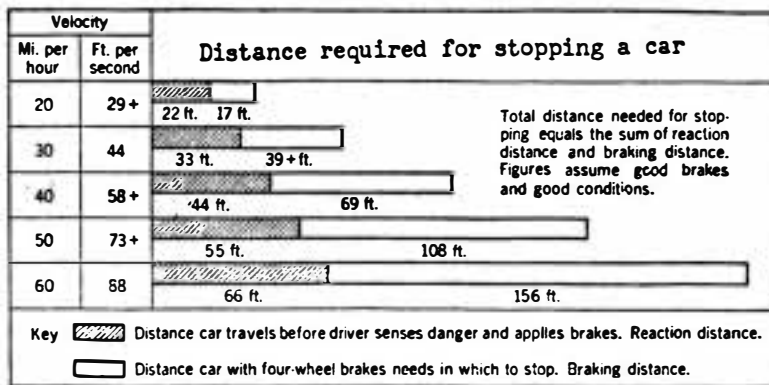
116. One out of ten cars has a defective air heater.

117. A person is likely to die when the carbon monoxide content of his blood becomes 50% saturated.

118. When a person is breathing air containing carbon monoxide, the percentage of carbon monoxide in the blood increases more rapidly during the first hour than during the second.

119. A person who for 3 hours breathes air containing 2 parts of carbon monoxide in each 10,000 parts of air is likely to get a headache.

120. More women die from carbon monoxide poisoning than men.



In items 121–27, mark answer space

- A. if the statement is **true** and these data support it
- B. if the statement is **probably true**, but these data do not support it
- C. if the statement is **false**, and its falsity is shown by these data
- D. if the statement is **probably false**, but its falsity is not shown by these data.
- E. if you **cannot determine** whether the statement is true or false, and these data give you no clue

121. A motorist traveling at 20 miles per hour takes the same number of seconds to apply his brakes after seeing the danger as he does at 60 miles per hour.

122. When he is traveling at 30 miles per hour, it takes about $\frac{3}{4}$ of a second for a motorist to apply his brakes after seeing the danger.

123. When the speed of the car is doubled, the brakes must be applied for about 2 times as great a distance.

124. More accidents which occur when a car is traveling at high speed are likely to be serious than those occurring at lower speeds.

125. A total distance of no more than about 113 feet is required to stop a car traveling 40 miles per hour on wet pavement.

126. The total distance needed for stopping is nearly 2 times as great for a car traveling 60 miles an hour as it is for a car traveling 40 miles an hour.

127. Men are better able than women to apply the brakes and bring a car to a stop.

**AVERAGE RETAIL FOOD PRICES IN UNITED STATES CITIES
FOR CERTAIN YEARS**

(Figures Show Cents per Pound)

YEAR	Food				
	Pork Chop	Bacon	Butter	Potatoes	Sugar
1910.....	19.2	25.5	35.9	1.7	6.0
1915.....	20.3	26.9	35.8	1.5	6.6
1920.....	42.3	52.3	70.1	6.3	19.4
1925.....	37.0	47.1	55.2	3.6	7.0
1930.....	36.2	42.5	46.4	3.6	6.1
1935.....	35.4	41.3	36.0	1.9	5.7
1940.....	27.9	27.3	36.0	2.4	5.2

CALORIES FOUND IN COMMON FOODS

FOOD	CALORIES PER POUND
Pork Chop	1,580
Bacon	3,000
Butter	3,410
Potatoes	385
Sugar	1,860

In items 128-31, mark answer space

- A. if the statement is true and these data support it
- B. if the statement is probably true, but these data do not support it
- C. if the statement is false, and its falsity is shown by these data
- D. if the statement is probably false, but its falsity is not shown by these data
- E. if you cannot determine whether the statement is true or false, and these data give you no clue

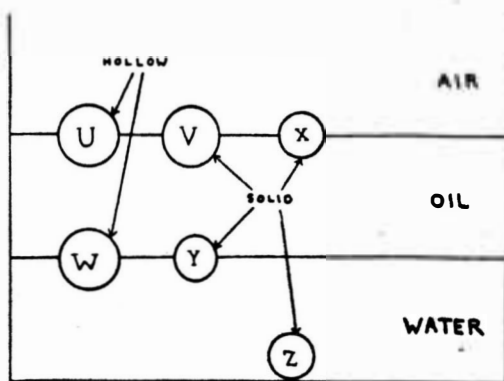
128. In 1940 a dollar's worth of potatoes yielded more Calories than a dollar's worth of butter.
129. In the period included on this chart the price of bacon was higher in 1921 than it was at any other time.
130. The average price of butter between 1915 and 1925 was higher than it was between 1935 and 1940.
131. During the period included on this chart none of the foods listed dropped to less than one-third of its price in 1920.

In the accompanying diagram, five spheres are shown floating in two layers of liquid while a sixth sphere lies at the bottom of the container.

Spheres U , V , and W have equal volumes

Spheres X , Y , and Z have equal volumes

The volume of X , Y , or Z is $\frac{1}{8}$ the volume of U , V , or W



In items 132–39 mark answer space

- A. if the statement is **true** and these data **support** it
- B. if the statement is **probably** true, but these data do not support it
- C. if the statement is **false**, and its falsity is **shown** by these data
- D. if the statement is **probably** false, but its falsity is **not** shown by these data
- E. if you **cannot determine** whether the statement is true or false, and these data give you no clue

132. Spheres U and V have the same weight.

133. Spheres U , V , and X all have the same weight.

134. Sphere Y weighs more than sphere X .

135. Sphere Z is definitely the heaviest of all the spheres.

136. Sphere W would not float in oil.

137. Neither sphere U nor V would float in water.

138. Sphere Z has a density greater than that of water.

139. Sphere Z has a greater density than that of any of the other solid spheres.